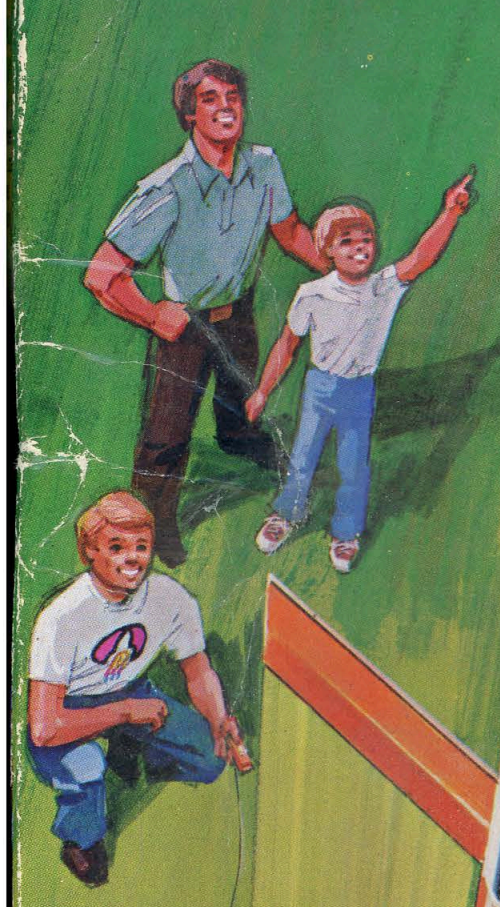
Challenger-1

FLYING MODEL ROCKETRY STARTER KIT

ESTES®

A DAMON COMPANY

Complete with everything you need for lift-off in minutes! (Less 6 volt lantern battery and glue.) Features high performance Challenger-1 rocket, complete launch control system and 3 safety certified model rocket engines.



This is a hobby kit requiring assembly. Recommended for ages 10 to adult. Adult supervision suggested for those under 12 years of age. 6 volt lantern battery and glue (not included), are required for assembly and operation.

EASY TO ASSEMBLE!
Ready-To-Launch In Less Than 30 Minutes!

THE HOBBY INDUSTRY OF AMERICA PROMOTES ACHIEVEMENT

4 Model reaches peak altitude and ejection charge activates recovery system.

5 Recovery parachute is deployed.

3 Model streaks skyward to peak altitude during coast phase.

2 High thrust and acceleration for powered flight.

6 Touch down and safe recovery . . . ready to blast-off again!

1 Rocket ignition and lift-off from electronically operated launch pad.

BUILD AND FLY ALL THE EXCITING KITS FROM ESTES.

More than 80 amazingly realistic flying model rockets including multi-stagers, scale vehicles, rocket powered gliders, and interplanetary voyagers. Plus solid propellant rocket engines, launch systems, telemetry devices, tech reports and much, much more!

Contains A or B type model rocket engines

D.O.T. Class C Toy Propellant Devices

Warning — Flammable:

Read instructions before use.

(Damaged, defective or unwanted engines should be destroyed by soaking in water.)

N.A.R. SAFETY CERTIFIED MODEL ROCKET ENGINES

A rewarding hobby for ages 10 to adult. Adult supervision recommended for those under 12 years of age.

ommended 6 volt
rn batteries:

- veready #731
- Ray-O-Vac #918
- Burgess TW-1
- N.E.D.A. Type #918

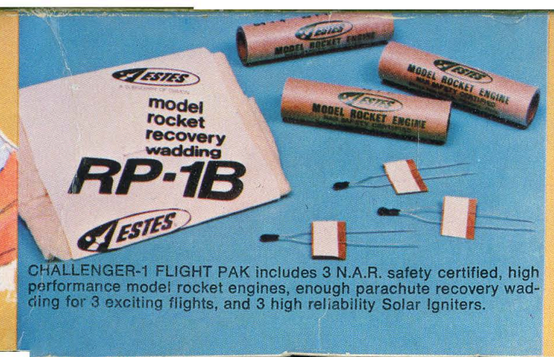
Recommended engines for Challenger-1 rocket:

1/2A6-2	A8-3	A8-5
B4-4	B6-4	C6-5

ESTES INDUSTRIES, PENROSE, COLORADO 81240

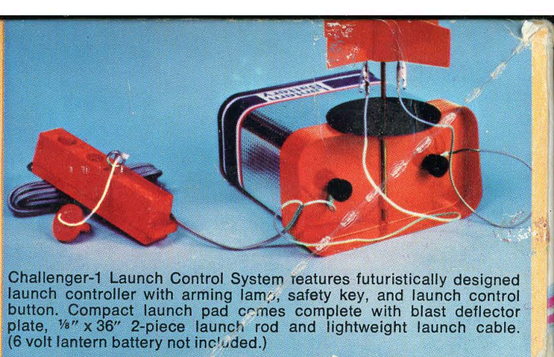
Everything you need for lift-off Today!

(Less 6 volt lantern battery and glue.)



CHALLENGER-1 FLIGHT PAK includes 3 N.A.R. safety certified, high performance model rocket engines, enough parachute recovery wadding for 3 exciting flights, and 3 high reliability Solar Igniters.

Challenger-1 rocket kit is easy-to-assemble with quick-release engine mount and bright orange plastic nose cone and fin unit. Features precolored white body tube and roll pattern decals for quick-finish decor. No painting required! Plus colorful 12" recovery parachute and special Beginner's Technical Manual .



Challenger-1 Launch Control System features futuristically designed launch controller with arming lamp, safety key, and launch control button. Compact launch pad comes complete with blast deflector plate, ⅛" x 36" 2-piece launch rod and lightweight launch cable. (6 volt lantern battery not included.)

ESTES®

A SUBSIDIARY OF DAMON

Challenger-1

Flying Model Rocketry Starter Kit

Read the assembly instruction sections of this manual carefully before beginning to put together your CHALLENGER-1 model rocket starter outfit. Even better, read this entire manual first so you will best understand the operation of each system.

Make sure you have all parts and materials before you start construction. As you assemble your rocket and launch equipment, follow the instructions in exact order. Check off each step as you complete it.

If you have not assembled electrical or electronic kits before, have a friend or relative who has done electronic kit assembly help you with the Launch System.

ESTES INDUSTRIES
PENROSE, COLO. 81240

Welcome to the exciting world of model rocketry. Your Challenger-1 starter outfit is designed to give you many enjoyable launchings and to provide you with necessary basic equipment as you build other kits and advance to launching designs of your own. This manual was prepared both to help you get perfect flights from your first model and to give you extra information you'll need as you go on to build other advanced model rockets.

TABLE OF CONTENTS

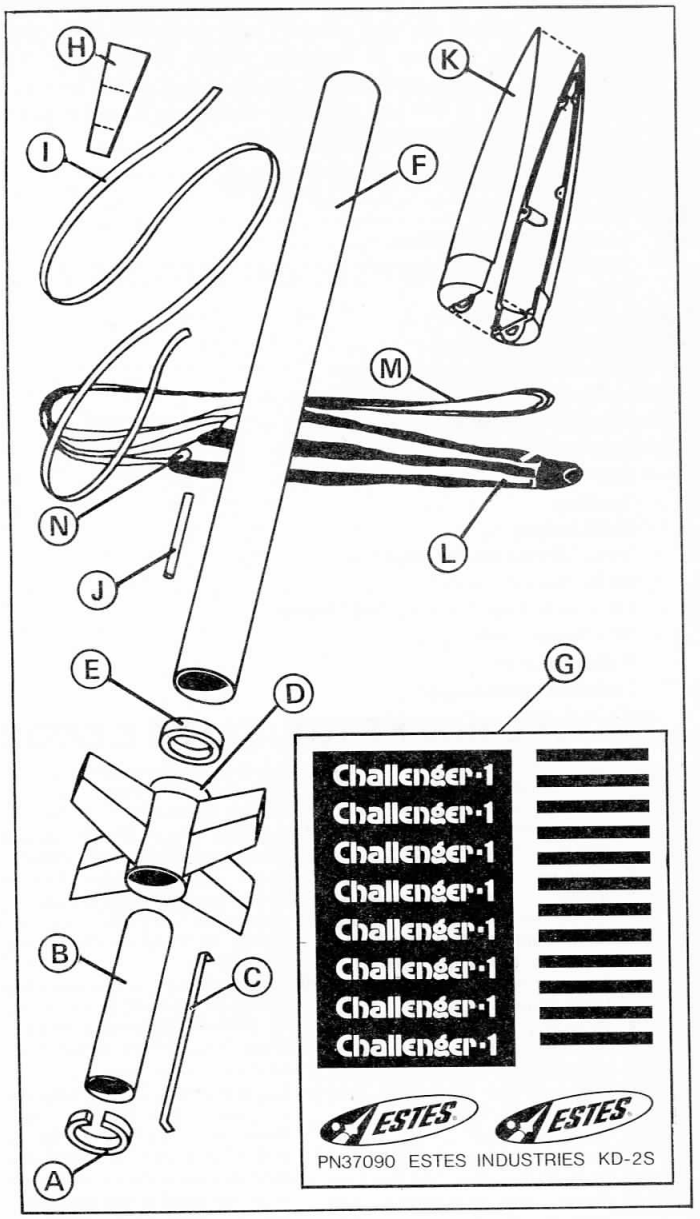
	Page
Rocket Assembly	2
Launch System Assembly	4
Testing The System	6
Flying Your Model	7
Countdown Checklist	7
Installing Igniters	7
Model Rocket Engine Operation	8
Model Rocket Flight Profile	9
Selecting Your Next Model	9
Recovery Systems	9
Stability	11
Tracking	12
Multi-Staging	13
Model Rocket Engine Selection	14
Model Rocket Engines	15
Estimating Your Rocket's Performance	15
Why Model Rocketry?	16
A Safe Program	16
Technical Publications	16

MODEL ROCKETRY SAFETY CODE

1. **Construction** — My model rockets will be made of lightweight materials such as paper, wood, plastic and rubber, without any metal as structural parts.
2. **Engines** — I will use only preloaded factory made model rocket engines in the manner recommended by the manufacturer. I will not change in any way nor attempt to reload these engines.
3. **Recovery** — I will always use a recovery system in my model rockets that will return them safely to the ground so that they may be flown again.
4. **Weight Limits** — My model rocket will weigh no more than 453 grams (16 ozs.) at liftoff, and the engines will contain no more than 113 grams (4 ozs.) of propellant.
5. **Stability** — I will check the stability of my model rockets before their first flight, except when launching models of already proven stability.
6. **Launching System** — The system I use to launch my model rockets must be remotely controlled and electrically operated, and will contain a switch that will return to "off" when released. I will remain at least 10 feet away from any rocket that is being launched.
7. **Launch Safety** — I will not let anyone approach a model rocket on a launcher until I have made sure that either the safety interlock key has been removed or the battery has been disconnected from my launcher.
8. **Flying Conditions** — I will not launch my model rocket in high winds, near buildings, power lines, tall trees, low flying aircraft, or under any conditions which might be dangerous to people or property.
9. **Launch Area** — My model rockets will always be launched from a cleared area, free of any easy to burn materials, and I will only use non-flammable recovery wadding in my rockets.
10. **Jet Deflector** — My launcher will have a jet deflector device to prevent the engine exhaust from hitting the ground directly.
11. **Launch Rod** — To prevent accidental eye injury I will always place the launcher so the end of the rod is above eye level or cap the end of the rod with my hand when approaching it. I will never place my head or body over the launching rod. When my launcher is not in use I will always store it so that the launch rod is not in an upright position.
12. **Power Lines** — I will never attempt to recover my rocket from a power line or other dangerous places.
13. **Launch Targets & Angle** — I will not launch rockets so their flight path will carry them against targets on the ground, and will never use an explosive warhead nor a payload that is intended to be flammable. My launching device will always be pointed within 30 degrees of vertical.
14. **Pre-Launch Test** — When conducting research activities with unproven designs or methods, I will, when possible, determine their reliability through pre-launch tests. I will conduct launchings of unproven designs in complete isolation from persons not participating in the actual launching.

This Solid Propellant Model Rocketry Safety Code Is Approved by The National Association of Rocketry and the Hobby Industry Association of America.

ROCKET ASSEMBLY



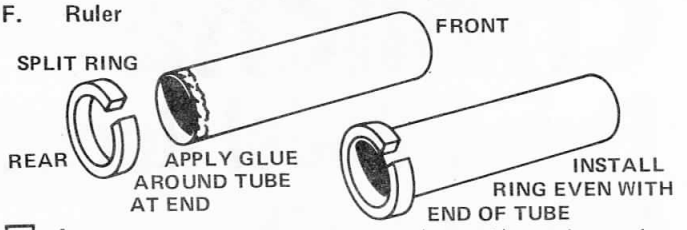
Locate the parts and materials listed below in your kit and lay them out on the table in front of you. (All rocket parts except the decal and plastic fin and nose cone are packed in one plastic bag.)

PARTS LIST

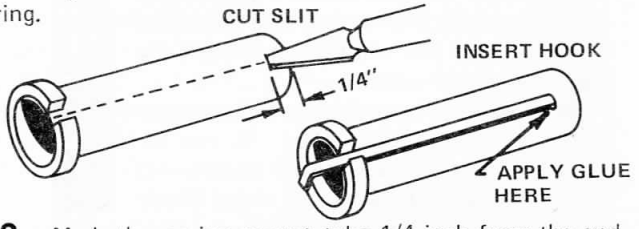
A)	1	Split Adapter Ring (type AR-2050S)	80425
B)	1	Engine Mount Tube (type BT-20J) 2-3/4 inches long	30326
C)	1	Engine Hook (type EH-2)	35025
D)	1	Plastic Fin Unit (type PRP-IG)	32486
E)	1	Adapter Ring (type AR-2050)	30164
F)	1	Body Tube (type WBT-50W) 9-1/2 inches long	30373
G)	1	"Water Transfer" Decal Sheet (type KD-2S)	37090
H)	1	Shock Cord Mount (type SCM-50)	84444
I)	1	Shock Cord (type SC-1) 18 inch elastic strip	85730
J)	1	Launch Lug (type LL-2B) 2-3/8 inch long	38178
K)	2	Nose Cone Halves (type PRP-1H)	32487
L)	1	Parachute (type PK-12A)	85564
M)	1	72" Shroud Line Cord (type SLT-72)	38237
N)	6	Tape Discs (type TD-3F)	38406

You will need a few tools and supplies, so collect them before you start. Here's the list:

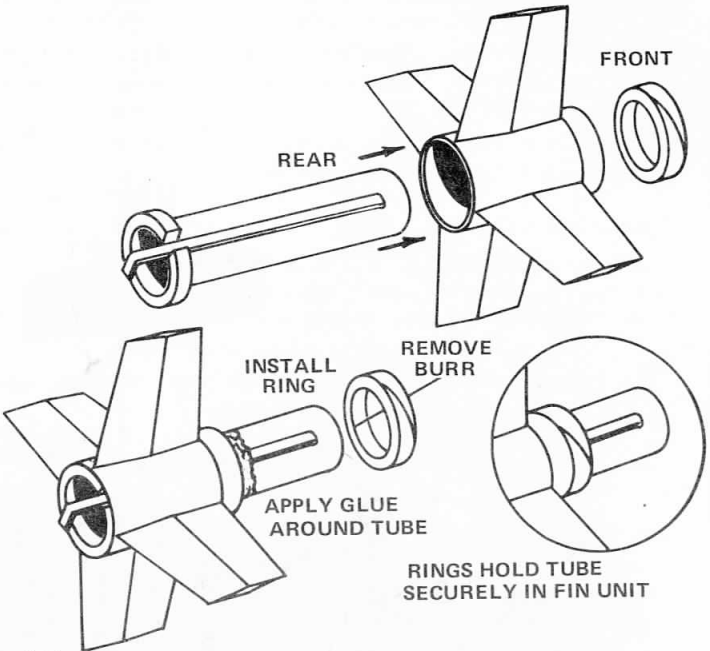
A. White Glue: Estes Rocket Glue, Elmer's, or similar.
B. Plastic Model Cement: Use cement made for styrene models.
C. Scissors: Almost anything that will cut paper is fine.
D. Knife: A sharp model knife or a single-edge razor blade.
E. Pencil: A ball point pen will do if you can't find a pencil.
F. Ruler



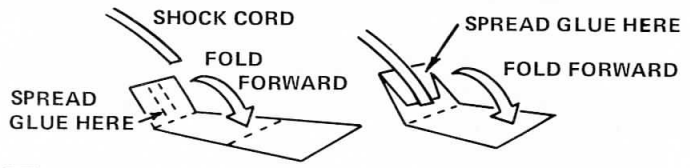
☐ **1** Glue the split adapter ring (part A) to the engine mount tube (part B). Apply a line of white glue around the outside of the engine mount tube at one end. Position the split ring over the glue so the end of the ring is even with the end of the tube and press the ring snugly around the tube. Wipe away any extra glue. Be sure to clean the extra glue from the gap in the ring.



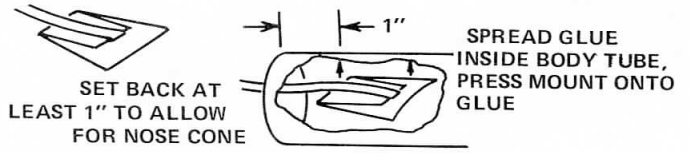
☐ **2** Mark the engine mount tube 1/4 inch from the end opposite the ring and on a straight line from the gap in the split ring. Use a sharp knife to cut a 1/8 inch long slit in the tube at the mark as shown. Make sure the slit is in line with the gap. Push one end of the engine hook (part C) into the slit and position the hook so it runs through the gap in the ring. Apply a drop of white glue to seal the front of the hook in the slit.



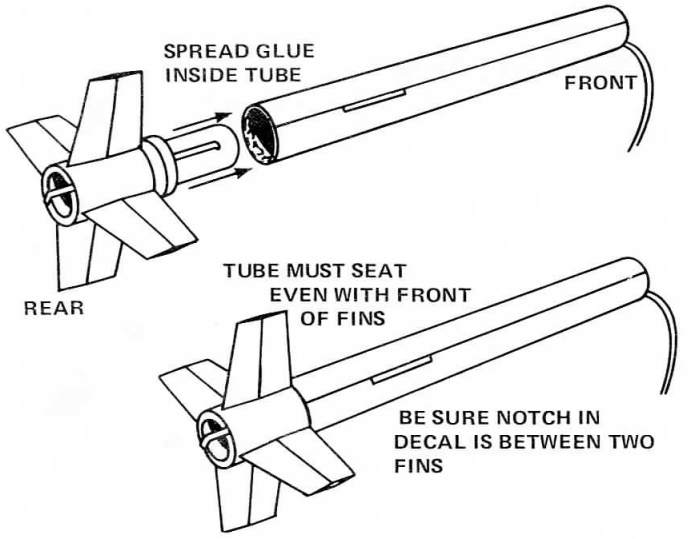
☐ **3** Slide the assembly from step 2 into the fin unit (part D) from the rear. The split adapter ring should fit completely into the fin unit. Apply a line of white glue around the engine mount tube 1/4 inch ahead of the front of the fin unit. Remove the "burr" from the inside of the adapter ring (part E) by mashing it flat with the side of your pencil. Slide the ring onto the engine mount tube, over the engine hook, and back tightly against the fin unit. Do not pause while installing the ring or the glue may "grab" with the ring in the wrong place.



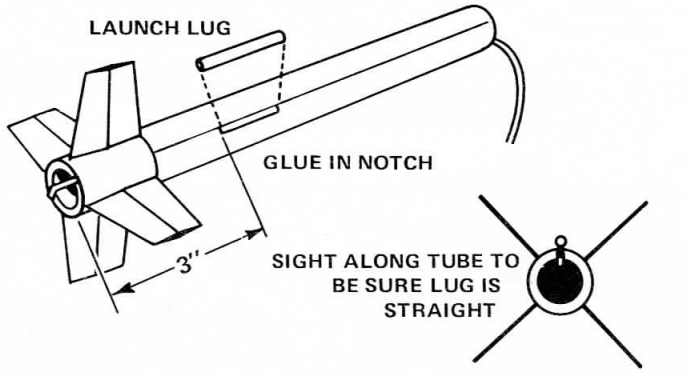
☐ **4** Cut out the shock cord mount (part H). Crease it on the dotted lines by folding. Spread white glue on the first section (1) and lay the end of the shock cord (part I) into the glue. Fold over and apply glue to the back of the first section and the exposed part of section 2. Lay the shock cord as shown and fold over again. Clamp the unit together with your fingers until the glue sets.



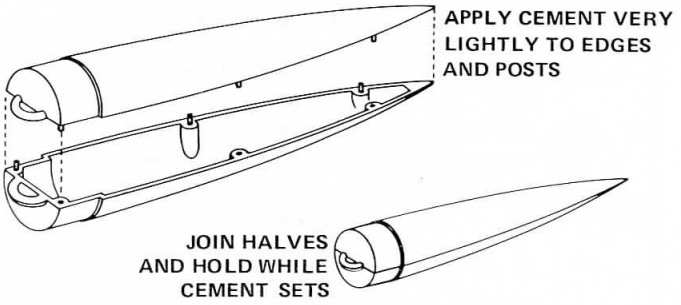
☐ **5** Apply white glue to the inside of the body tube over an area 1 inch to 2 inches from one end. The glued area should be the same size as the shock cord mount. Press the mount into the glue as shown and hold it until the glue sets.



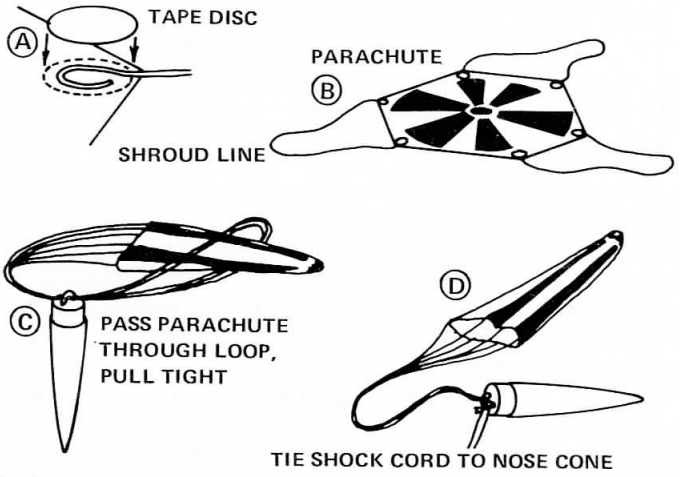
☐ **6** Spread white glue around the inside of the body tube at the end opposite the shock cord mount. The glue should cover an area extending 1/2 inch into the tube. Insert the front of the fin unit into the rear of the body tube. The tube should "seat" evenly and tightly against the shoulder on the fin unit.



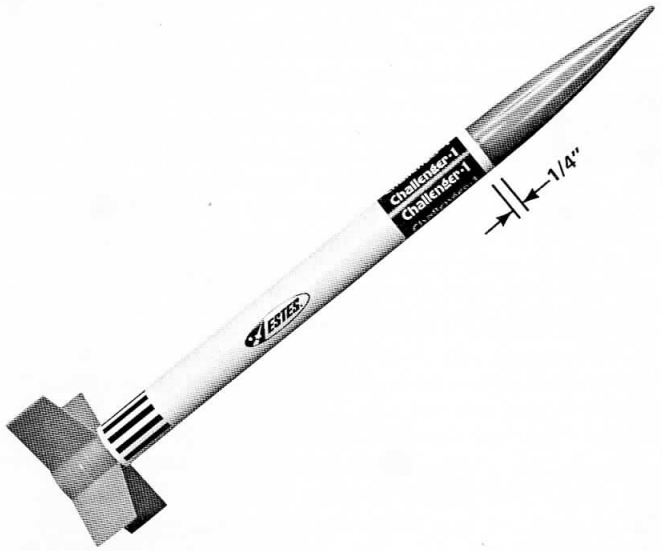
☐ **7** Glue the launch lug (part J) to the body tube between two fins, 3" ahead of the rear of the model as shown. (Use white glue.) Sight along the tube to be sure the launch lug is straight on the body.



☐ **8** Glue the two nose cone halves (part K) together using plastic model cement. Be careful to not use too much or you will have a sloppy-looking joint. Make sure the alignment pins on the inside of the cone fit completely into their matching holes.

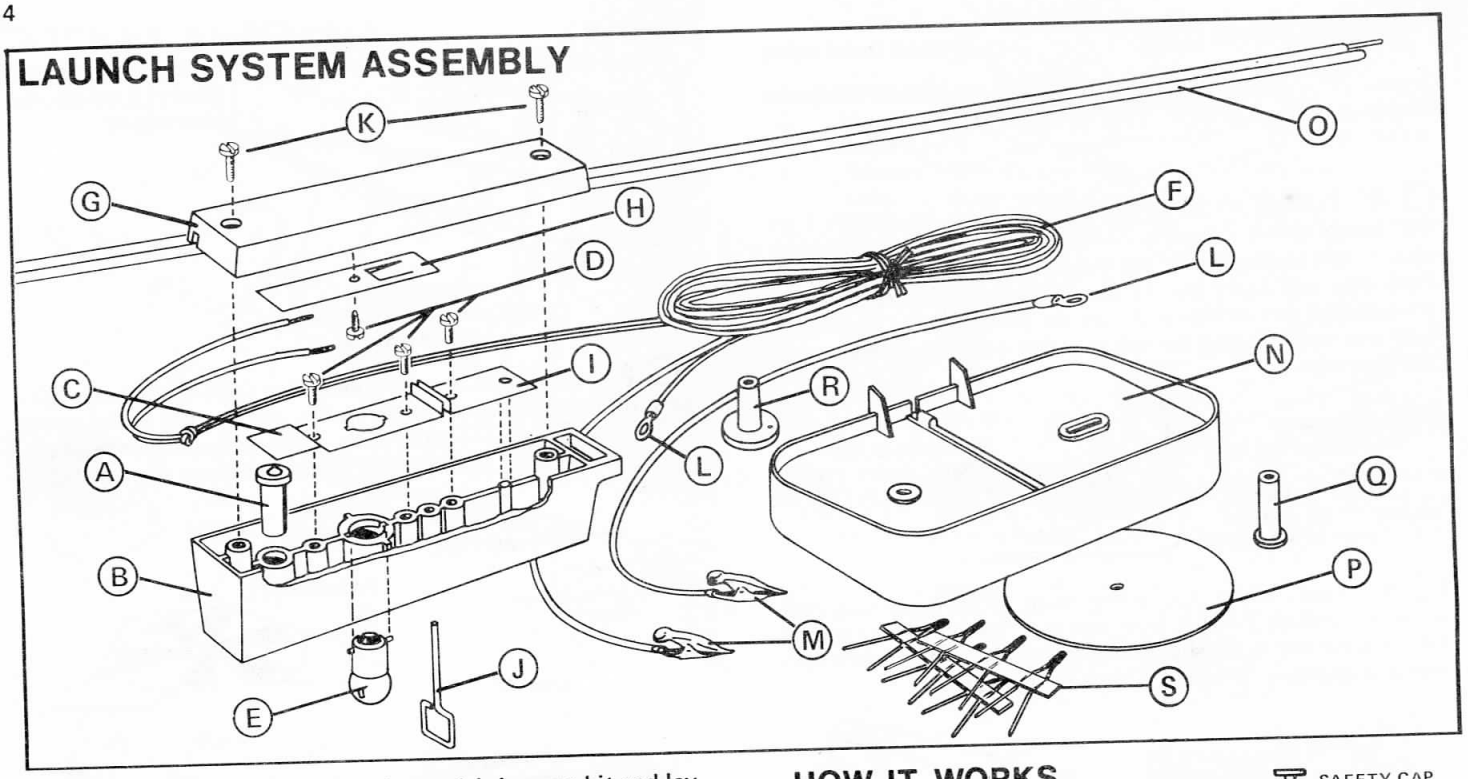


☐ **9** Cut out the parachute (part L) on its edge lines. Cut three 24 inch lengths of shroud line (part M). Attach line ends to the top of the parachute with tape discs (part N) as shown. Pass the shroud line loops through the ring at the rear of the nose cone. Pass the parachute through the loop ends and draw lines tight against the ring. Set the knot with a drop of glue. Tie the free end of the shock cord to the ring.



☐ **10** Apply decals (part G). Cut out a decal section, dip it in lukewarm water for 10 seconds, and hold it until it uncurls. Slip the decal off the backing sheet and onto the model. Blot excess water away. Apply all decals as shown in the photograph. For best results, let the model dry overnight and apply a coat of clear spray to protect the decals.

LAUNCH SYSTEM ASSEMBLY



Locate the following parts and materials in your kit and lay them out on the table in front of you. (All launcher parts except the plastic pieces, wire, and launch rod are packaged together in a small plastic bag.)

PARTS LIST

A)	1	Switch Button (type PRP-1A)	32485
B)	1	Control Unit Case Top (type PRP-1B)	32484
C)	1	Upper Contact Strip (type FSS-4D)	38065
D)	4	Short Screws (type ST-4019)	45125
E)	1	Continuity Check Light Bulb (type AL-12)	38021
F)	1	12 foot Lead Wire (type LW-24KB)	85835
G)	1	Control Unit Case Bottom (type PRP-1C)	32483
H)	1	Lower Contact Strip (type FSS-4E)	38066
I)	1	Terminal Contact Strip (type FSS-4F)	38067
J)	1	Safety Interlock Key (type FSK-10)	33155
K)	2	Long Screws (type ST-4050) 1/2 inch long.	45126
L)	2	Terminal Lugs (type TL-188)	38146
M)	2	Micro-Clips (type MC-1)	38121
N)	1	Launch Pad Unit (type PRP-1D)	32482
O)	1	2-Piece Launch Rod (type RLR-1A)	02235
P)	1	Blast Deflector (type BD-3)	38034
Q)	1	Rocket Support Stand-Off (type PRP-1E)	32489
R)	1	Rod Safety Cap (type PRP-1F)	32488
S)	2	Strips Solar Igniters (type NWI-2)	85550

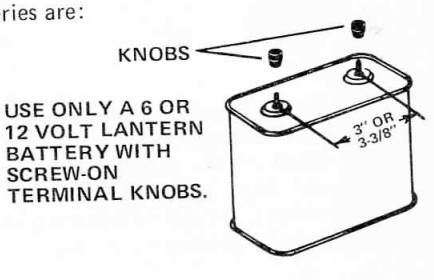
The tools you will need for assembly are a sharp knife, a small or medium size screwdriver, pliers, ruler, and scissors. If you have not assembled electrical or electronic kits before, have a friend or relative who has done electronic kit assembly help you.

IMPORTANT: BATTERY

This launch system is designed to use either 6 or 12 volt heavy duty lantern batteries (NEDA types 918 or 926). Either 6 or 12 volt batteries are suitable for use with Estes Solar igniters (supplied with this starter outfit). For use with standard Estes Astron igniters 12 volt batteries are recommended. Typical recommended batteries are:

6 Volt
Eveready #731
Ray-O-Vac #918
Burgess #TW-1
RCA #VS317

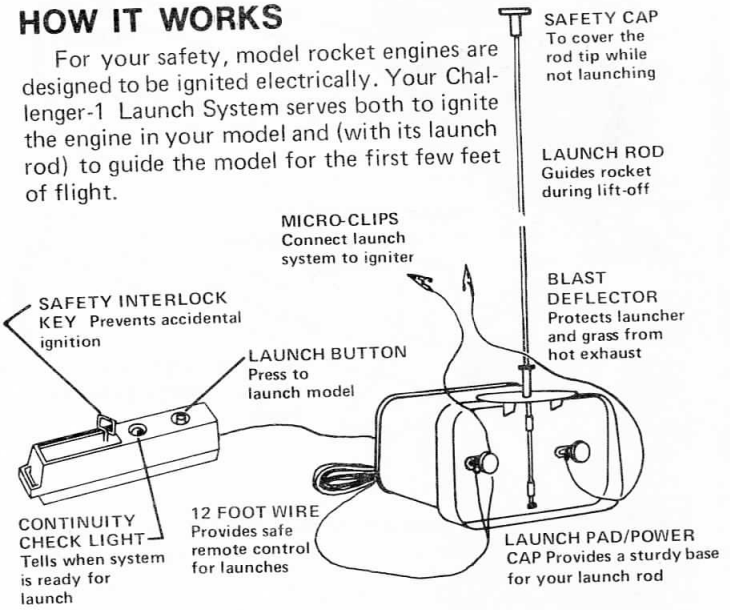
12 Volt
Eveready #732
Ray-O-Vac #926
Burgess #TW-2
RCA #VS342

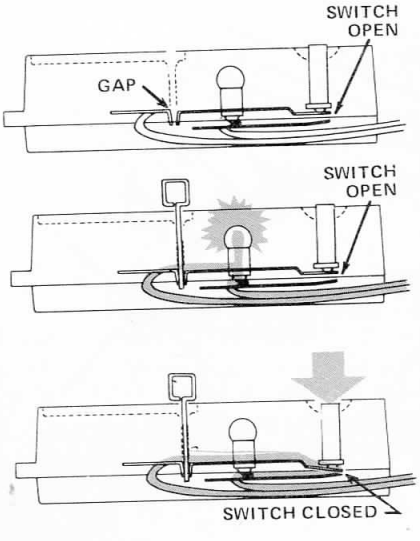


USE ONLY A 6 OR 12 VOLT LANTERN BATTERY WITH SCREW-ON TERMINAL KNOBS.

HOW IT WORKS

For your safety, model rocket engines are designed to be ignited electrically. Your Challenger-1 Launch System serves both to ignite the engine in your model and (with its launch rod) to guide the model for the first few feet of flight.

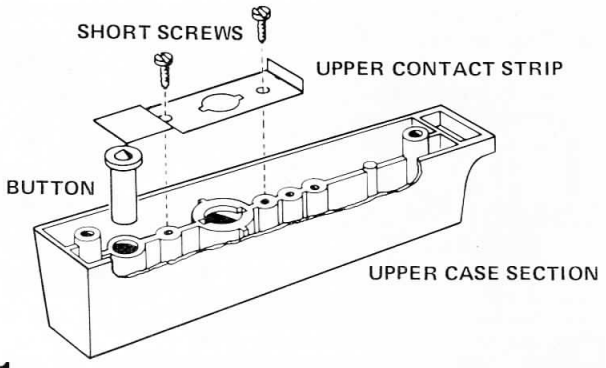

SAFETY CAP
To cover the rod tip while not launching
LAUNCH ROD
Guides rocket during lift-off
MICRO-CLIPS
Connect launch system to igniter
BLAST DEFLECTOR
Protects launcher and grass from hot exhaust
SAFETY INTERLOCK KEY Prevents accidental ignition
LAUNCH BUTTON
Press to launch model
CONTINUITY CHECK LIGHT
Tells when system is ready for launch
12 FOOT WIRE
Provides safe remote control for launches
LAUNCH PAD/POWER
CAP Provides a sturdy base for your launch rod



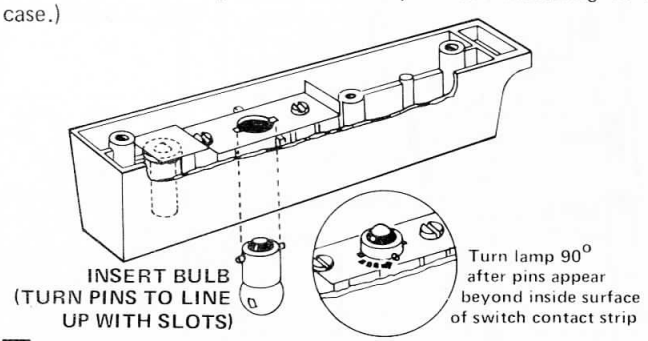
The safety interlock key is left out while the launcher's micro-clips are attached to the engine igniter. Electricity cannot flow through the gap in the circuit.

Inserting the safety interlock key "arms" the circuit, allowing electricity to flow through the light. The light should glow, showing that the circuit is properly hooked up and ready to go.

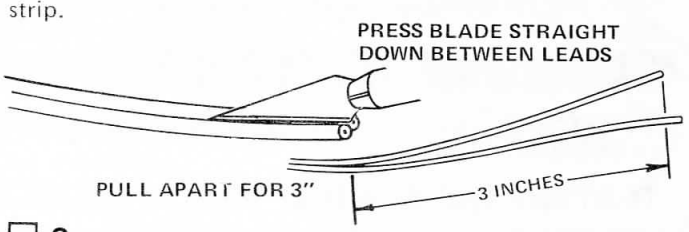
Pushing the "launch" button closes the main switch. The electric current passes through the switch instead of being "used up" by the light bulb. The full current then flows through the igniter wire which in turn glows red hot and ignites the model rocket engine.



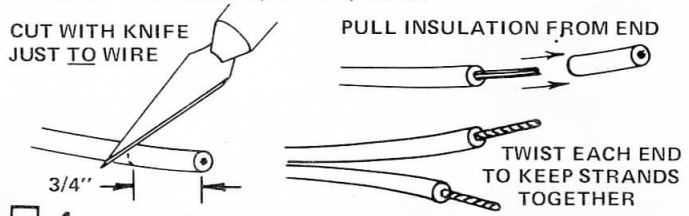
☐ **1** Insert the switch button (part A) into place in the control unit case top (part B) from the inside. Position the upper contact strip (part C) in the case as shown. Start two short screws (part D) into the holes to hold the strip--do not tighten these screws yet. (OPTIONAL: Paint the switch button with black enamel paint and let dry before installing in the case.)



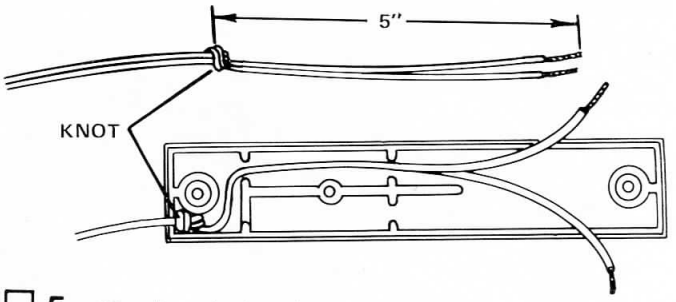
☐ **2** Push the bulb (continuity check light bulb, part E) into its hole in the upper case. Turn it so the pins on the bulb's base line up with the slots in the case and in the contact strip. When the pins have been pushed through the contact strip, give the bulb a quarter turn to keep it from falling out. With the bulb in place, tighten the two screws holding the contact strip.



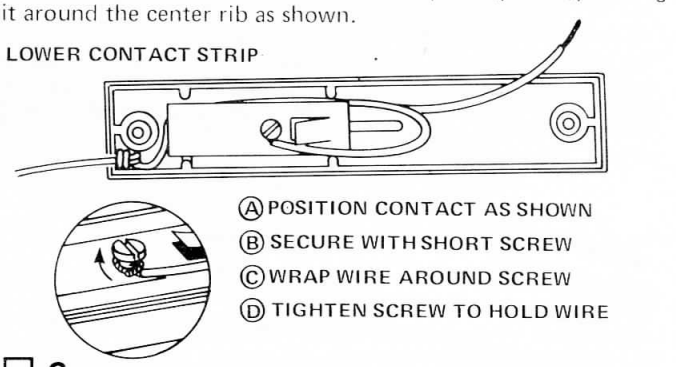
☐ **3** Separate the two halves of the wire (part F) for a distance of about 3 inches at one end. To do this, lay the wire end flat on a table. Push a knife blade down between the two plastic insulation sections at the end. Work carefully to avoid damaging the wire, hurting yourself, or scratching the table. Pull the two wires gently apart to separate them. (If this is done correctly, both wires will still be completely covered with insulation when this step is completed.)



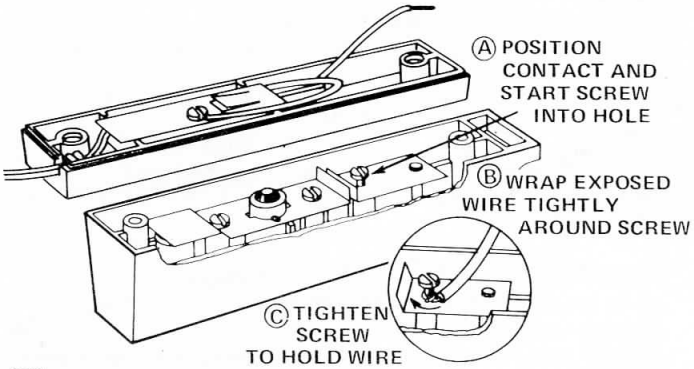
☐ **4** Strip 3/4 inches of insulation from each of the separated ends of the wire. To strip insulation, lightly cut into the plastic 3/4 inch from the end. Slice down just to the copper wire itself, but not into the wire. Do this very carefully to avoid cutting the small individual wires. Rotate (roll) the wire as you slice to cut just through the insulation all around. Pull the insulation off. Twist the stripped end to keep the many little individual wires together. Repeat with the other stripped end.



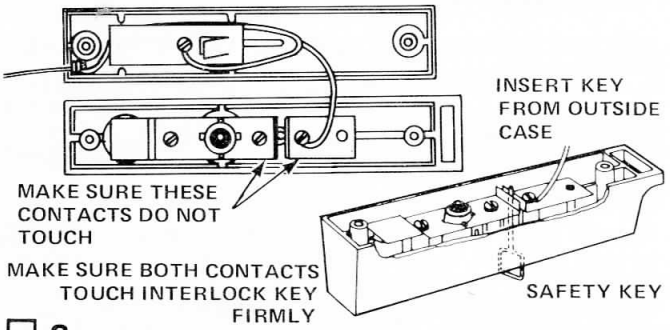
☐ **5** Tie a knot in the wire about 5 inches from the stripped end. Lay the wire into the case bottom piece (part G), routing it around the center rib as shown.


LOWER CONTACT STRIP
Ⓐ POSITION CONTACT AS SHOWN
Ⓑ SECURE WITH SHORT SCREW
Ⓒ WRAP WIRE AROUND SCREW
Ⓓ TIGHTEN SCREW TO HOLD WIRE

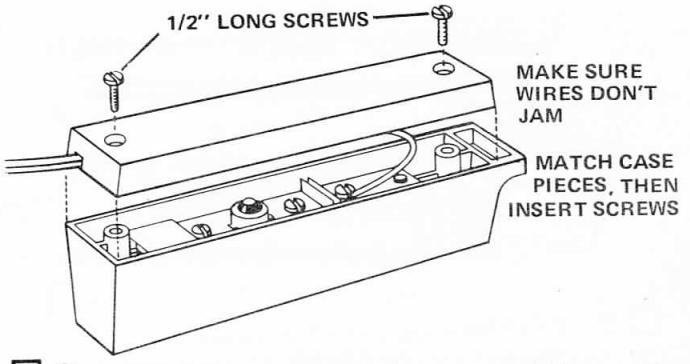
☐ **6** Position the lower contact strip (part H) in the case bottom. The raised cut-out in the strip should be toward the center of the case. Start a short screw into the hole, but don't screw it in more than halfway. Wrap one bare wire end tightly around the screw in a clockwise direction and tighten the screw.



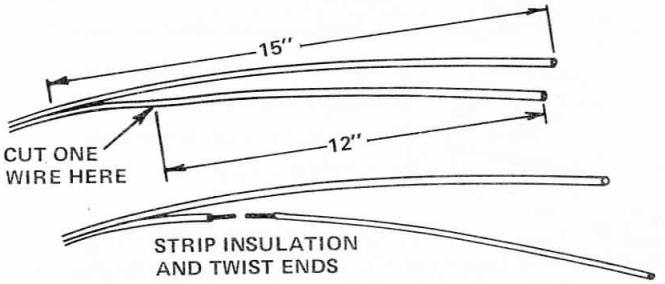
☐ **7** Position the terminal contact strip (part I) in the case top. Start the remaining short screw into the hole, but don't screw it in more than halfway. Loop the remaining exposed wire end tightly around the screw (in a clockwise direction). Tighten the screw to hold wire and contact firmly in place.



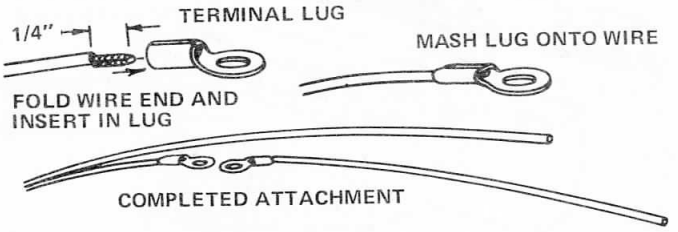
☐ **8** Check now to be sure the safety interlock will operate correctly. Look closely to make sure the two interlock contacts do not touch. Then insert the key (part J) from the outside of the case and make sure it touches both contacts. If it doesn't touch both, check all other parts of the assembly for correct fit. If everything else checks out OK, then carefully bend the contacts until they will both touch the key but not each other.



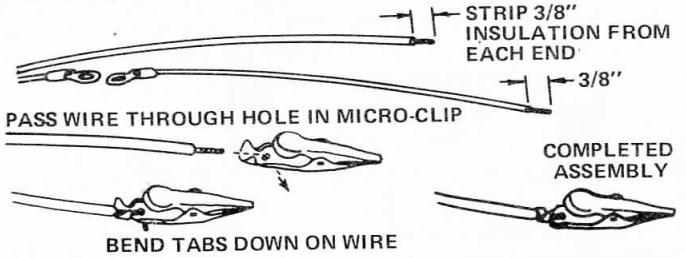
☐ **9** Place the case bottom over the case top. Make sure the wires lie neatly beside the contacts and are out of the way of the bulb contact and the case sides. Insert the two long screws (part K) to hold the two case pieces together. Tighten the screws for a firm fit, but do not force the screws in too tightly.



☐ **10** Separate the two halves of the wire at the end opposite the control unit for a distance of 15 inches. Cut one of these two wires 12 inches from its end. Strip 1/2 inch of insulation from the end of the shorter side of the main wire and from one end of the 12 inch wire. Twist each bare wire end to hold the strands together.

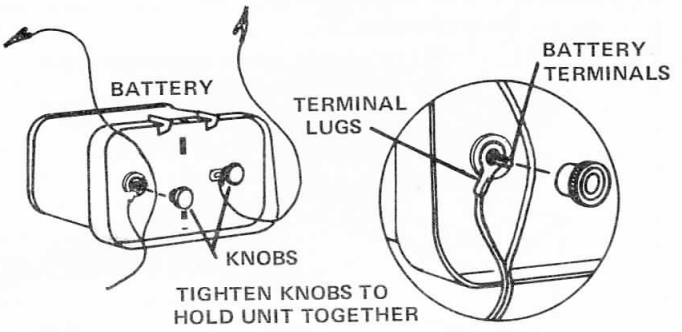


☐ **11** Fold a bare wire end (from step 10) in half. Push the bare wire into the sleeve on a terminal lug (part L) and squeeze the sleeve down tightly on the wire with a pair of pliers. Repeat with the other bare wire and terminal lug.

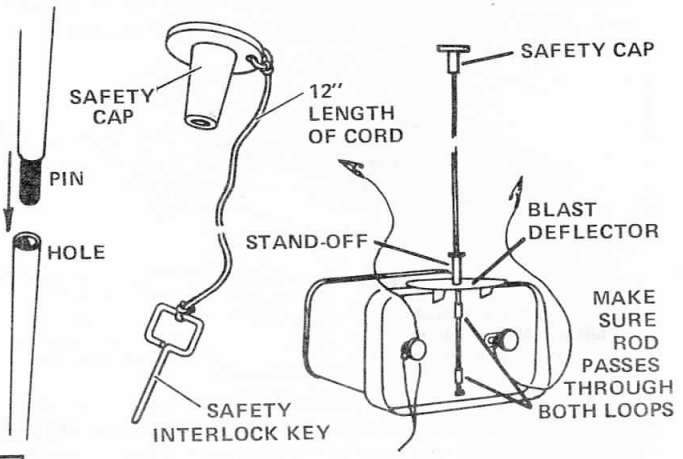


☐ **12** Strip off 3/8 inch of insulation from the two remaining wire ends and twist the ends. Attach a micro-clip (part M) to each wire end. Too attach a micro-clip, push the wire end down through the small hole in the bottom of the clip. Lay the wire down between the tabs so the insulation is just behind the tabs. Fold the tabs down tightly on the bare wire. Fold the end of the wire which sticks out through the small hole back along the bottom of the clip. (For best results, solder the wire to the clip.)

For best safety and reliability we suggest you connect the safety interlock key to the safety cap (part R) with a one or two foot cord to keep from losing the key and to remind you to remove the cap before launching.



☐ **13** Place the launch pad unit (part N) on the end of the battery. Notice that the battery's terminal bolts will fit through the holes in the pad unit only when it is turned the correct way. Place the terminal lugs over the terminal bolts as shown and screw on the knobs which came with your battery.

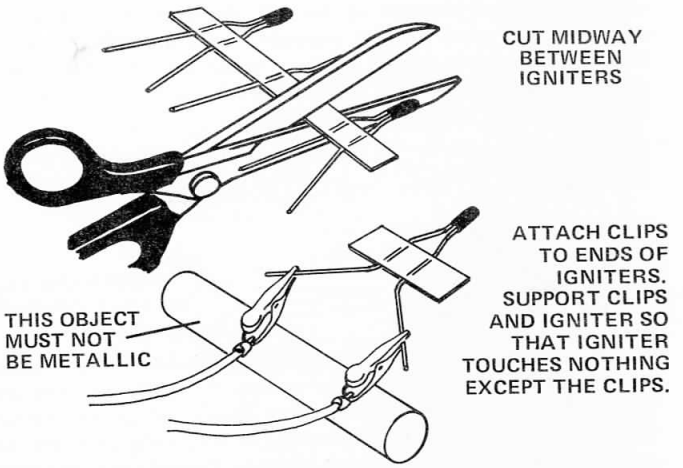


☐ **14** Join the launch rod sections (part O). Insert the pin on the one rod section into the hole in the end of the other rod section. Tap the assembled rod lightly on a concrete floor to firmly join the sections. Mount the rod on the launch pad unit. Slide the blast deflector (part P) down the rod so it rests on the supports on the pad. Slip the stand-off (part Q) onto the rod. Install the safety cap (part R) on the end of the rod.

IMPORTANT: ALWAYS CAP THE ROD WHEN NOT LAUNCHING ROCKETS.

TESTING THE SYSTEM

An extra strip of Estes Solar igniters is supplied in this Starter Outfit for use in testing and as spares in case of misfires. Cut the tape between igniters to separate them.


CUT MIDWAY BETWEEN IGNITERS
ATTACH CLIPS TO ENDS OF IGNITERS. SUPPORT CLIPS AND IGNITER SO THAT IGNITER TOUCHES NOTHING EXCEPT THE CLIPS.
THIS OBJECT MUST NOT BE METALLIC

Connect the micro-clips to the ends of the wires on the igniter. SUPPORT CLIPS AND IGNITER SO THEY DON'T TOUCH ANYTHING. (DO NOT hold the igniter in your hand when the second clip is being connected.)

Insert the safety interlock key firmly into its hole. The continuity check light should now glow. Press the launch button. The igniter should flash. (At the same time the continuity check light should go out.) If the system does not function correctly, check the battery and the wiring until you find the problem and correct it. Use the following chart to trace the problem.

CONTROL SYSTEM TROUBLE SHOOTING

PROBLEM	CAUSE	CURE
Continuity check light does not glow, igniter does not flash.	Bad connections in wiring. Battery dead. Micro-clips dirty. Leads broken. Safety interlock key not making contact.	Check all connections, check battery, clean clips and touch them together to see if bulb lights, insert safety key in hole completely.
Continuity check light glows, but igniter does not flash.	Launch controller does not make contact, weak battery or poor battery connections. Micro-clips touching or shorted through launch rod or blast deflector plate.	Check controller wiring, check battery strength, check battery clip connections. Move micro-clips away from blast deflector and launch rod.
Igniter flashes, but the check light does not glow.	Check light bulb not installed correctly, light burned out.	Clean contact surfaces on bulb and socket, replace pilot bulb.
Igniter flashes as soon as clips are connected to it, even with safety interlock out.	Short circuit in controller.	Rewire controller carefully, following instructions.
Igniter flashes when the key is inserted without pressing launch button.	Controller contact strips bent, loose wire pieces in controller.	Straighten controller contact strips, clean out inside of controller.
Lamp glows when key is not in place.	Short circuit across interlock contacts.	Bend contacts so a connection can be made only by the interlock key.

REMOVE KEY FROM CONTROL IMMEDIATELY AFTER EACH LAUNCH.

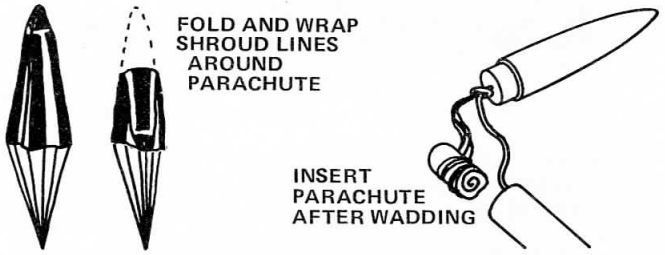
FLYING YOUR MODEL

After your rocket has been finished and your launch system carefully built and tested, you are ready for the big moment---the launch.

COUNTDOWN CHECKLIST

Be sure to follow the HIAA - NAR Model Rocketry Safety Code when carrying out all your model rocketry activities.

T-14 Pack four squares of loosely crumpled flameproof recovery wadding into body tube. *(See page 10-Recovery Hints)*

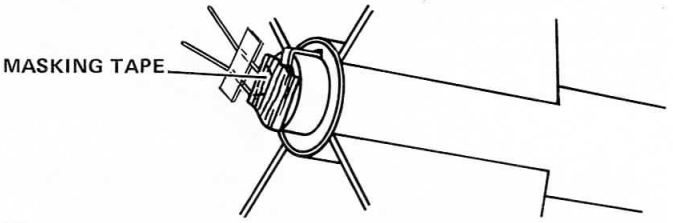


T-13 Fold the parachute into a slim triangular shape as shown. Fold the "triangle" in half lengthwise and form it into a smooth, round shape. Wrap the shroud lines around the parachute and insert it into the rocket body. If 'chute is too large, unfold it and repack until it slides easily into rocket. A fit that is too tight may prevent parachute from ejecting properly.

NOTE: DO NOT pack parachute until you are actually ready to launch. For maximum parachute reliability, lightly dust the 'chute with ordinary talcum powder before each flight, especially in cold weather.

T-12 Pack shock cord neatly into rocket, then slide nose cone into place. Nose cone should separate easily from rocket body tube, but should not be extremely loose. If it is too tight, sand inside of body tube end and shoulder of nose cone with extra fine sandpaper.

If nose cone is too loose, add a wrapping of transparent tape or masking tape to the shoulder of the nose cone.

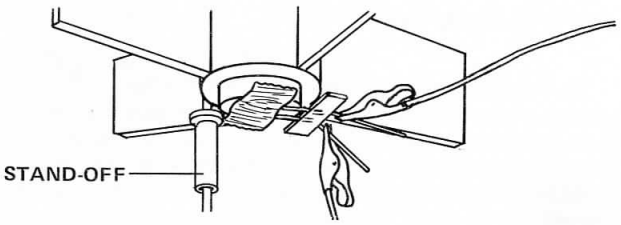


T-11 Select an engine and install an igniter as directed in the igniter installation instructions. Engines recommended for use with this rocket are the ½A6-2, A8-3, A8-5, B4-4, B6-4, and C6-5 made by Estes. Insert engine into rocket. Engine hook must latch securely over end of engine.

Use an A8-3 engine for your first flight.

T-10 Disarm the launch panel---remove safety key.

T-9 Remove rod safety cap. Place rocket on launch pad. Slide the rocket's launch lug over the end of the launch rod and lower the rocket to the stand-off. Make sure rocket slides freely on launch rod.



T-8 Clean the micro-clips. Attach one micro-clip to each lead of igniter. Clips must not touch each other, and igniter leads must not cross.

T-7 Clear the launch area, alert recovery crew and trackers. Check for low flying aircraft and unauthorized persons in the recovery area. Make sure there is no dry grass or other burnable material within 3 feet of launch pad.

T-6 Arm the launch panel--insert safety key. Start final countdown: **"5 4 3 2 1 LAUNCH!!"** Press launch button and hold until rocket lifts off. Release the launch button as soon as the rocket leaves the launch pad. Remove the safety interlock key and install the safety cap on the launch rod.

MISFIRE PROCEDURE

Occasionally the igniter will heat and burn into two pieces without igniting the engine. This is almost always caused by a failure to install it correctly. Disarm the launch panel, remove the model, clean the igniter residue from the nozzle, and install a new igniter. Follow the launching procedure again.

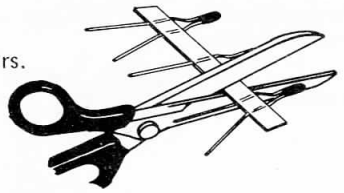
INSTALLING IGNITERS

The care with which you install the igniter in the engine for your model will determine whether your model flies or not. Read this section carefully if you want your model to fly the first try every time.

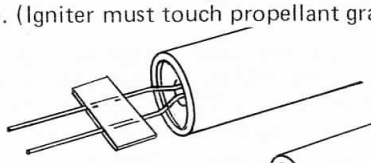
To ignite an engine a spot on the exposed surface of the propellant inside the nozzle must be heated to a very high temperature. When you press the launch button, a strong electric current flows through the igniter wire, heating the wire red hot. This ignites the coating on the igniter which burns, heating the propellant until it ignites.

BUT WAIT! For this to happen the igniter must be touching the propellant in the engine when the coating on the igniter burns. If it doesn't touch, nothing happens! There are a lot of things which can keep the igniter from touching the propellant, and any of them will keep your rocket from flying. Here's the right way to install your Solar igniters.

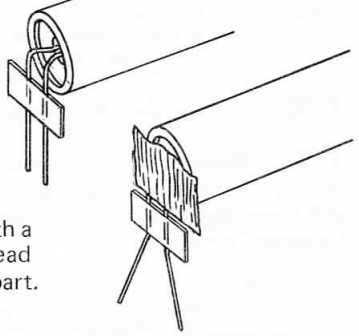
1. Cut tape to separate igniters.



2. Insert coated end of igniter into engine nozzle as far as possible. (Igniter must touch propellant grain.)



3. Bend igniter leads flat to the nozzle.



4. Secure igniter in nozzle with a piece of masking tape. Spread ends of igniter about 1" apart.

We recommend Solar igniters, part number 2301, for use with this launch system. Standard Astron igniters may also be used. However, there will be a slight delay between the time the launch button is pressed and the time the engine ignites. Installation instructions for Astron igniters are included with Estes engines.

WHAT CAN GO WRONG?

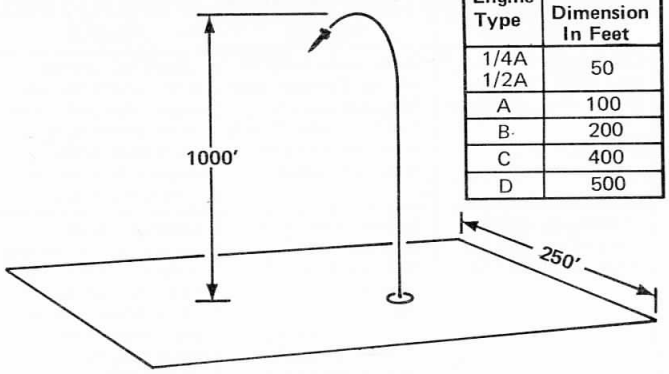
PROBLEM	CAUSE	CURE
Igniter coating burns; engine does not ignite.	Igniter was not touching propellant; dirt in nozzle.	Remove igniter and clean nozzle with toothpick or similar object. POINT NOZZLE AWAY FROM YOU WHILE YOU CLEAN IT. Install a fresh igniter carefully, making sure it touches propellant.
Igniter burns through tape and falls out of engine--coating may or may not burn.	See above. Also; igniter leads crossed, weak battery, or thin tape.	Reinstall igniter carefully making sure leads do not cross, check battery strength.
Light glows; igniter does not heat at all.	Clips or leads shorted (touching each other).	Make sure clips do not touch launch rod or blast deflector. Check wiring in control handle.
Light glows weakly and/or flickers slightly; igniter does not heat.	Bad connections--probably micro-clips.	Clean and reattach micro-clips. Check battery clips. Check all other connections.
Light does not glow at all when key is inserted.	Dead batteries. Bad micro-clip or battery clip connections. Bad connections inside control handle. Bulb burned out. Damaged igniter.	Clean micro-clips. Check battery clips. Check battery. Check bulb. Check all wiring against assembly instruction. Try fresh igniter in circuit.

ALWAYS REMOVE THE SAFETY KEY FROM THE PANEL BEFORE APPROACHING A MODEL WHICH HAS MISFIRED.

LAUNCH AREA

Choose a large field away from power lines, tall buildings, tall trees and low flying aircraft. For your first flight try to find a field at least 250 feet square. MAKE SURE THE AREA WHERE YOU SET UP YOUR LAUNCHER IS CLEAR OF OBSTRUCTIONS AND HAS NO DRY WEEDS OR HIGHLY FLAMMABLE MATERIALS.

Engine Type	Minimum Dimension In Feet
1/4A 1/2A	50
A	100
B	200
C	400
D	500



In choosing a launch area, the larger the better. Football fields and playgrounds are often fine. The chart above shows the smallest recommended sizes. Remember, the larger the launch area, the better your chance of recovering your rocket.

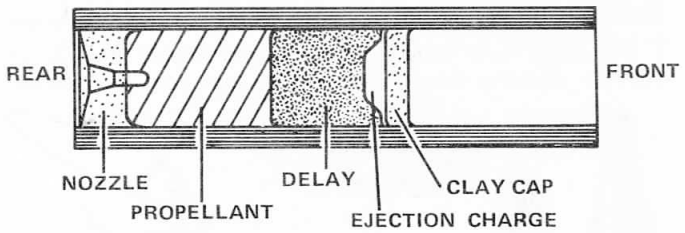
WEATHER CONDITIONS

Wind is the biggest problem for model rocketeers. A high performance model, descending on its parachute, can drift a long way in a strong wind. If you want to get your model back, launch in light breezes or, when possible, in calm weather. You can make some allowance for wind conditions by tipping your launcher to point into the wind, but never tip it more than 25° from straight up.

Never launch near a thunder storm. Remember too, that plastic parachutes become stiff in cold weather and will not open easily. If launching below 40° Fahrenheit (about 4° Celsius), use extra care in preparing your model, especailly the recovery system.

MODEL ROCKET ENGINE OPERATION

Let's spend a moment looking at how the engine for your model operates. Model rocket engines are solid propellant devices. The picture gives an idea of what an engine would look like if you could see into the center of it.



Starting at the rear (the business end), there's a nozzle. The nozzle serves to control and aim the flow of exhaust gases from the engine. It is at the nozzle where the engine actually gets its "push".

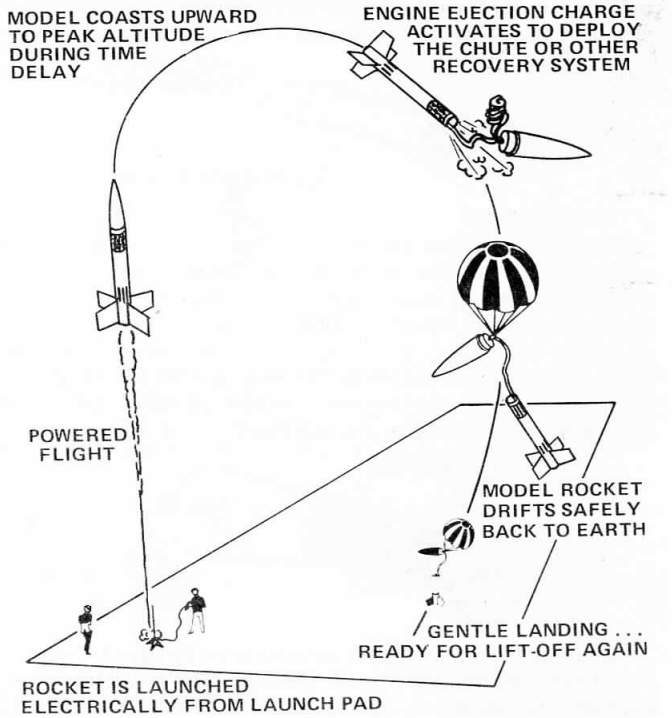
Ahead of the nozzle is the propellant itself. Once ignited, the propellant burns, starting at the nozzle, to produce heat and much gas which is controlled by the nozzle to produce thrust. In standard model rocket engines, the propellant burns in cigarette fashion, starting at one end and proceeding to the other.

After the propellant comes the delay charge. The delay charge is ignited by the propellant as the propellant finishes burning. The delay also burns in cigarette fashion, but much more slowly than the propellant. Depending on the engine, it may take the delay from 2 to 7 seconds to burn from one end

to the other. The delay serves two purposes: It lets the rocket coast upward to maximum altitude, and it produces a smoke trail to make it easier to follow (track) the rocket.

As the delay finishes burning it ignites the ejection charge. The ejection charge produces a lot of gas quickly, and because there is nothing to hold it back, most of it blows out through the front of the engine. This puff of gas, just like when you blow through a pea-shooter, forces the nose cone, parachute, and wadding out the front of the rocket.

MODEL ROCKET FLIGHT PROFILE


MODEL COASTS UPWARD TO PEAK ALTITUDE DURING TIME DELAY
ENGINE EJECTION CHARGE ACTIVATES TO DEPLOY THE CHUTE OR OTHER RECOVERY SYSTEM
POWERED FLIGHT
MODEL ROCKET DRIFTS SAFELY BACK TO EARTH
GENTLE LANDING . . . READY FOR LIFT-OFF AGAIN
ROCKET IS LAUNCHED ELECTRICALLY FROM LAUNCH PAD

After each flight remove the used engine by springing the engine hook back and pulling on the end of the engine. Inspect the model to be sure that everything is in order and you're ready to set up for another flight.

SELECTING YOUR NEXT MODEL

You've flown your first model several times, you've had a lot of fun, and now you're ready to build another bird. So where do you go from here? Another sport model such as the Alpha or Antares will be great for practicing your building skills. Perhaps you want to move up to a payload-carrying bird like the Icarus. Or you might choose something big and impressive like the Big Bertha. The choice is yours, but you will have more fun if you start with fairly simple designs and work up slowly to the big, "super" rockets like the 1/100th scale Saturn V.

SKILL LEVEL

To make it easier for you to decide which kit you want to build, Estes Industries has developed a skill level rating system for model rocket kits. The easier a kit is to build, the lower its skill level number. Here's what the numbers mean.

SKILL LEVEL	DESCRIPTION	TO BE BUILT BY	KIT COLOR CODE
1	Very Simple	Beginning Rocketeer	Orange
2	Fairly Easy	Intermediate Rocketeer	Purple
3	Average	Craftsman Rocketeer	Blue
4	Challenging	Advanced Rocketeer	Green
5	Extremely Challenging	Expert Rocketeer	Red

As you advance you'll want to try your hand at scale models such as the V-2, Honest John, Saturn V, and Space Shuttle. You'll build extra-high-flying multi-stage models and demonstrate your craftsmanship with high performance boost-gliders. If science is your "thing", you'll probably do research projects using instrument payloads like the Transroc telemetry transmitter and the Cineroc aerial movie camera.

You'll find the technical information offered by Estes Industries a real help. Technical reports, plans, and issues of the Model Rocket News, America's most widely-read model rocket publication, will give you the information you need to develop your own advanced designs.

EAC MEMBERSHIP

For maximum enjoyment of the world's most exciting hobby, model rocketry, join the Estes Aerospace Club. You will be joining with more than 80,000 fellow rocketeers in the most exciting rocket club on earth.

As an EAC member you will receive a special club membership kit featuring a special Viper rocket kit designed exclusively for EAC members, handsome membership wall certificate, iron-on EAC insignia for a t-shirt or jacket, EAC decal sheet, range box stickers, EAC stationery, a special EAC product bulletin, and a subscription to Spectra the official club newsletter. Membership in the Estes Aerospace Club opens up a whole new world of exciting model rocketry activities.

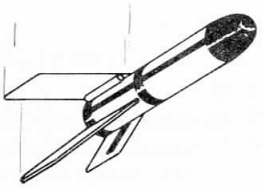
(To request an official EAC membership brochure and application write: Estes Industries, Dept. 185, Penrose, Colorado 81240.)

RECOVERY SYSTEMS

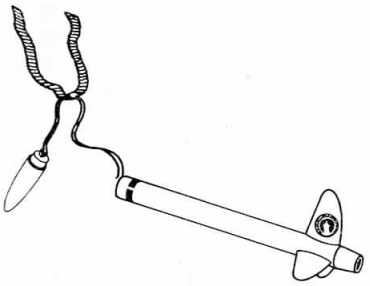
The recovery system is one of the most important parts of a model rocket. It provides a safe way to return the rocket and its payload to earth after the model reaches its peak altitude. Beyond this, recovery systems can be fun when rocketeers compete to see who can keep his rocket in the air the longest. Too, there's always room for the sharp rocketeer to develop something new and better for recovery.

A model rocket recovery system depends on drag (or wind resistance) to slow the rocket. It changes the model from a streamlined object to one which the air can "catch against" to slow its descent. Here's a brief description of the six main recovery methods:

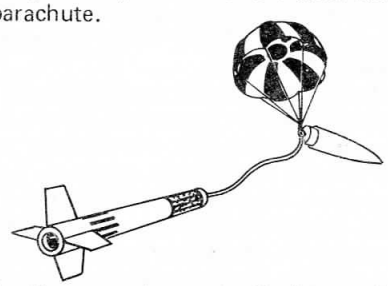
1) Featherweight Recovery (example--Streak): The model is very light (under 1/4 ounce without engine) and has a blunt nose. The ejection charge kicks the engine out of the rocket. Without the engine the model is so light compared to its size that it falls slowly. The empty engine casing tumbles back safely.



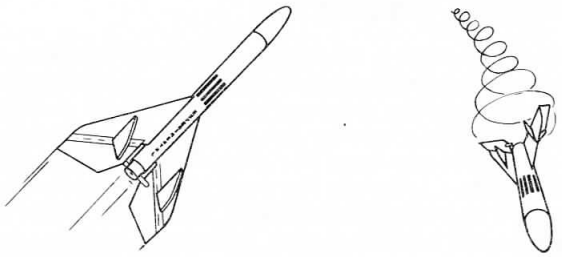
2) Tumble Recovery (example--Scout): The ejection charge forces the engine rearward in the model. This moves the balance point of the rocket back, making the rocket aerodynamically unstable. The rocket starts to tumble, and the air drag on the tumbling rocket is so high that the rocket falls slowly.
(Estes Pat. No. 3,114,317)



3) Streamer Recovery (example--Sprint): A streamer creates enough drag to keep the rocket from falling very fast. The larger the streamer, the slower the descent of the rocket. A streamer can bring back a rocket gently without the long sideways drift with the wind which can occur with a parachute.



4) Parachute Recovery (example--Challenger-1): The parachute is pushed out of the body tube by the ejection charge. The parachute fills with air and creates tremendous drag. Since the rocket is attached to the parachute, the rocket floats back to the ground very gently.



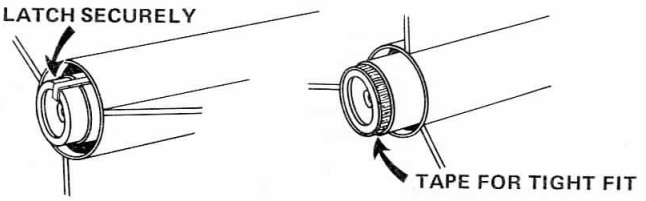
5) Helicopter Recovery (example--Gyroc): Vanes on the model are activated by the ejection charge. The vanes catch the air in a way that makes the rocket spin as it falls. This spin creates high drag which keeps the rocket from falling very fast.

6) Glide recovery (example--Sky Dart): A boost-glider is launched vertically like a conventional rocket. The ejection charge causes the model to convert to a glider. The wings of the glider generate lift to make the rocket glide through the air instead of falling. (Estes Pat. No. 3,157,960 and 3,452,471)

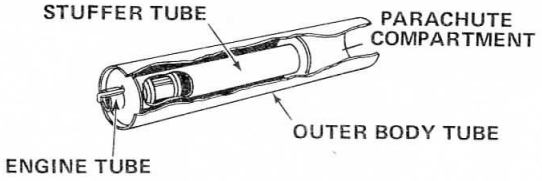
RECOVERY HINTS

No one likes to see a carefully built model damaged because the recovery system didn't work right. Failures in the recovery come in almost every case from errors in building the model or in preparing it for flight.

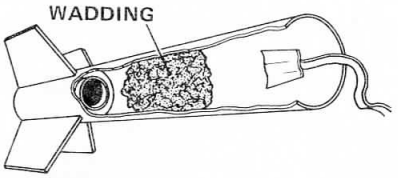
Most model rockets use a parachute or streamer. The most common problem with these is failure to install the engine correctly. If the engine is not held securely, it will be ejected instead of the parachute or streamer. If your model has an engine hook, make sure it latches securely over the end of the engine. If the engine is to be held in place by a friction fit, wrap it with enough masking tape to be sure it fits tightly.



Another problem comes from leaving a hole that the ejection gases can leak through. A bad engine mount design or sloppy construction can do this, and the ejection gases will go right out the hole without moving the parachute. Make sure the rear of your rocket is airtight when the engine is in place.



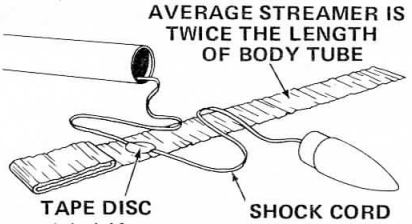
Extra-large models can often be made more reliable by using a stuffer tube. The stuffer reduces the volume of space that the ejection charge must pressurize, giving more force to eject the nose cone and 'chute. A stuffer is usually made from BT-20 or BT-50 body tube, centered inside the model's body with paper rings glued on each end. The rings should also be glued to the inside of the rocket body so ejection gas can't leak into the space between the stuffer and the body.



Whether the model has a parachute or streamer, always be sure to use enough flameproof wadding. The wadding not only protects the parachute (or streamer) from being damaged by the hot ejection gases, but it also works as a gas seal and piston to help the ejection gases push the parachute out of the rocket's body tube. Wadding should always be loosely crumpled and inserted into the body until it fills the body for a distance at least twice the body tube diameter.

RETRIEVING YOUR MODEL

For high altitude models parachute recovery is often too good; the "bird" can be a mile away by the time it finally touches down. Streamer recovery is often the answer. A strip of 1 inch wide flameproof crepe paper, usually at least twice as long as the model, will bring the model back safely, but much closer to the launch pad than with a parachute.



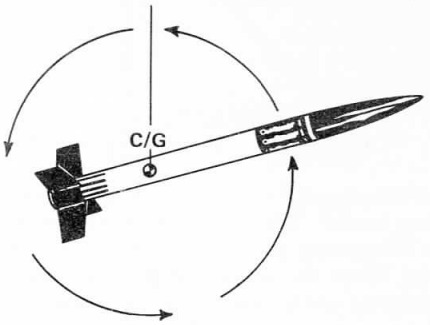
If your model drifts very far on its way down, you'll need some extra tricks to help find it once it lands. As you watch the rocket come down, also look for a landmark that is as close as possible to being in line with the model. A tree, house, electric power pole, or fence post might be your mark. Then if you can't see the model itself when it lands, you can search a straight line from your launch site to the landmark to find the rocket.

Avoid painting your model a color that will blend with the ground or vegetation. Camouflage paint jobs look nice, but they help lose rockets. Bright orange is one of the best colors to help you find your rocket after its flight.

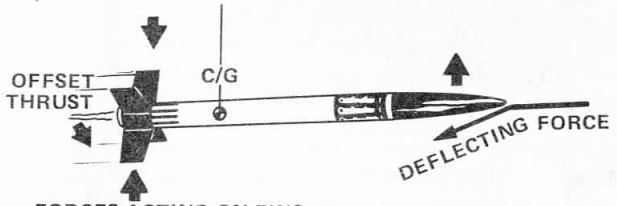
STABILITY

One of the first things a model rocket designer learns is that a vehicle will not fly unless it is aerodynamically stable. By stable we mean that it tends to keep its nose pointed in the same direction throughout its upward fight. Good aerodynamic stability keeps the rocket on a true flight path even though some force (such as wind) tries to turn the model off course.

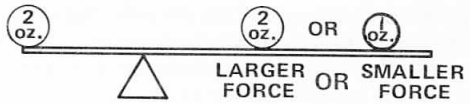
If a model is not stable, it will constantly turn its nose away from the intended flight path. As a result, it tries to go all over the sky, but ends up going "nowhere". An unstable rocket will usually tumble to earth after the engine burns out, damaging the model.



When a free-flying object rotates, it always rotates around its balance point. (The proper term for the balance point is the center of gravity, abbreviated as C.G.) The balance point (C.G.) is the pivot for all forces trying to turn the rocket.

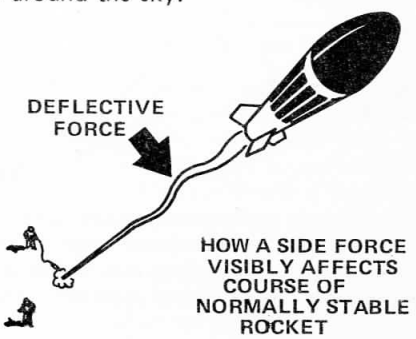


The strongest forces acting on a model rocket in flight are the thrust of the engine, the action of air on the nose, and the action of air on the fins. Off-center thrust from engine misalignment and forces on the nose try to bring the nose of the rocket around to the rear. These forces are opposed by the aerodynamic forces acting on the fins. The effect of these forces increases with greater distance from the location of the force to the center of gravity.



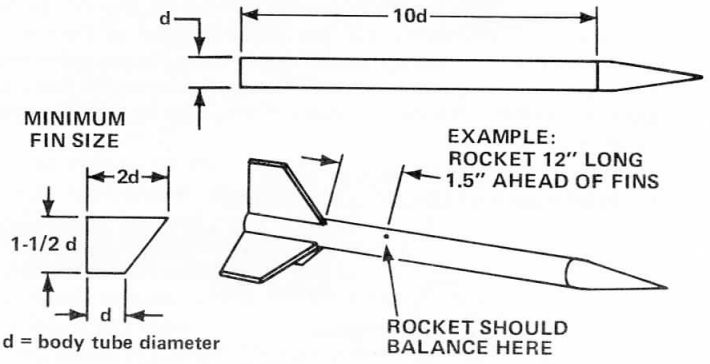
(large force X small distance = small force X long distance)

As long as the forces on the fins of the rocket are great enough to counteract the forces on the nose and any off-center thrust, the rocket will fly straight. If the fins are too small and/or too close to the center of gravity, there will not be enough force to counteract the force on the nose. As a result, the nose will swing out to the side and the model will try to chase itself around the sky.



The side forces on the nose and fins of a rocket are very small while it flies straight. When something disturbs the rocket and it starts to turn sideways, the side forces on both nose and tail increase. (There is some aerodynamic force on the body. However, it is small and can usually be ignored.) Depending on the size and shape of the nose and fins and their distances from the center of gravity, one will overpower the other and force the rocket to turn its way. If the nose overpowers the fins, it's too bad. However, if the fins overpower the nose, the rocket will swing back into line and continue on its way.

Although determining the exact relationships between various forces on a model rocket requires higher mathematics, certain practical rules can be used by the beginning rocketeer to design stable rockets. The first rule is to use a long body. Until you have considerable experience in designing models, use a body tube that is at least 10 times as long as its diameter. This makes it easier to get enough distance between the center of gravity and the fins.



The second rule is to make the fins large. The larger the fins, the more force they will produce when the rocket starts to turn. For the first few designs, use a fin which is at least as large as the example in the illustration.

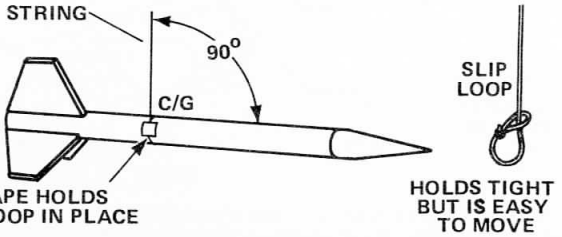
The third rule is to place the fins as far back on the rocket as possible. Generally, this means that the rear edge of the fin will meet the rear end of the body; and the fin will be swept back (like on a jet fighter). Do not place any fins ahead of the center of gravity.

Finally, the rocket should balance at a point at least 1/8 of its length ahead of the front of the fins. This gives the fins the "leverage" they will need to counteract the force on the nose.

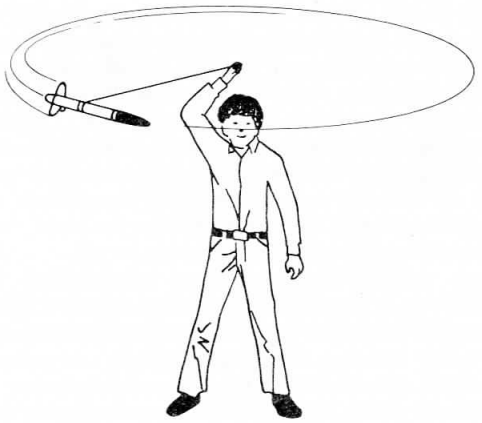
Remember that these rules are general; they are based on experience rather than precise mathematical analysis. Always remember to test your model for stability before you launch it.

TESTING FOR STABILITY

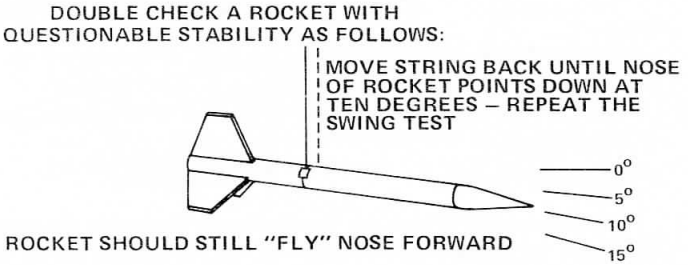
The easiest way to test the stability of a model is to fly it--without launching it. Do this by attaching a string to the model and swinging it through the air. If the string is attached at the rocket's C.G., its behavior as it is swung through the air will tell what it will do in powered flight.



To test your model, form a loop in the end of a six to ten foot long string. Install an engine in the rocket. (The center of gravity is always determined with an engine in place.) Slide the loop to the proper position around the rocket so the model balances horizontally. Apply a small piece of tape to hold the string in place.



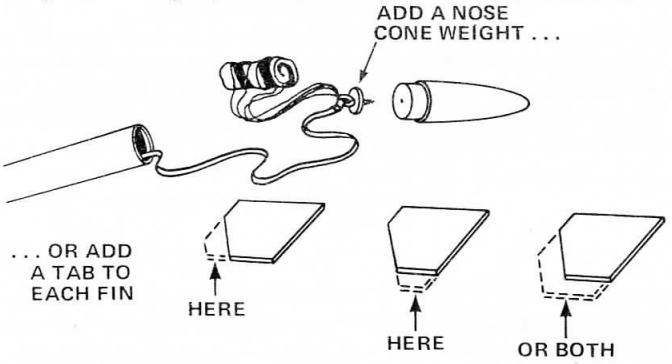
With the rocket suspended at its center of gravity, swing it overhead in a circular path. If the rocket is very stable, it will point forward into the wind created by its own motion. Some rockets which are stable will not point forward of their own accord unless they are started straight. Hold the rocket in one hand with the arm extended and then pivot the entire body to start the rocket in the circular path. It may take several attempts to get a good start.


DOUBLE CHECK A ROCKET WITH QUESTIONABLE STABILITY AS FOLLOWS:
MOVE STRING BACK UNTIL NOSE OF ROCKET POINTS DOWN AT TEN DEGREES – REPEAT THE SWING TEST
0°
5°
10°
15°
ROCKET SHOULD STILL "FLY" NOSE FORWARD

If you have to hold the rocket to start it, make this additional test to determine whether the model is stable enough to fly: Move the loop back on the body until the body tube points down at a 10^{o} angle below the horizontal. Repeat the swing test. If the model will keep its nose pointed ahead once started, it should be stable enough to launch.

Be careful when swinging a rocket overhead: A collision with a nearby object or person could be serious. Always do your testing in an open, uncluttered area.

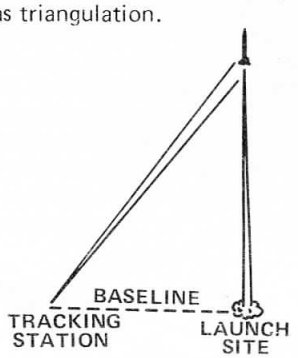
Don't try to fly a rocket that has not passed the test. Most unstable rockets loop around in the air harmlessly. However, a marginally unstable model can make a couple of loops and then become stable due to the lessening of the propellant load. If this happens at the wrong time, the model might crash into the ground at high speed.



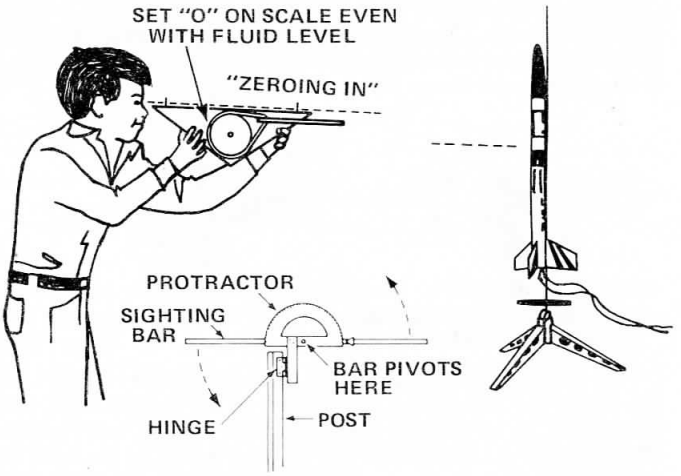
If your rocket does not pass the stability test, it can usually be made stable. Two methods will work: Move the balance point forward or enlarge the fins. To move the balance point forward, attach nose cone weights to the base of the nose cone. Fins can either be replaced with larger ones or extra tabs can be glued to the rear or tip edges of the fins. (Some scale models use supplementary plastic fins.) After making your changes, test the model again to be sure it is now stable.

TRACKING

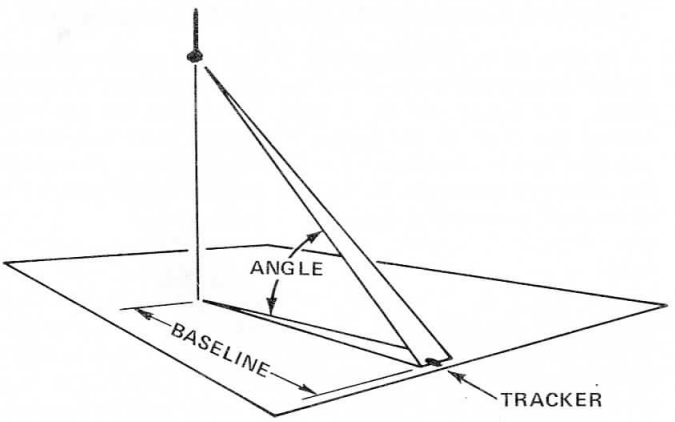
Every rocketeer wants to know how high his models fly. Many methods of determining a model's peak altitude have been tried, but only one method has proven itself. This method is known as triangulation.



The simplest form of triangulation uses only one very simple tracking device. With it, the rocketeer measures the angle between the ground and the line of sight to the rocket at its peak altitude. When this angle and the distance from the tracker to the launcher are known, it is very easy to determine the altitude.



The Estes Altiscope is the best basic tracking device. A workable tracker can also be made from "scratch" by the rocketeer. A plastic or metal protractor, mounted securely on a post set in the ground, with a sighting stick pivoted at the "center" of the protractor, will do the job. The tracking device must be set so that it reads 0^{o} when aimed at the rocket on the launcher and 90^{o} when aimed straight up. If the tracker is not "zeroed in" on the launcher, the altitude reading will be wrong.

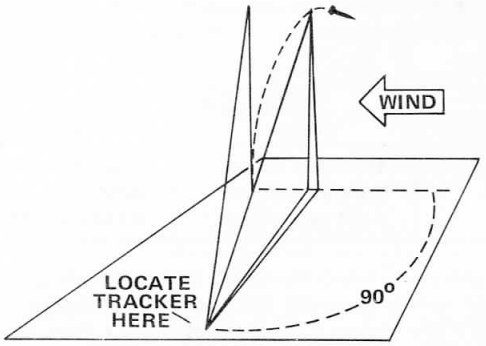


When the operator at the tracking station is ready, the rocket is launched. He follows the rocket with his tracker as it rises. When it reaches its peak altitude he stops or "locks" the tracker. The indicated angle is then read from the protractor scale.

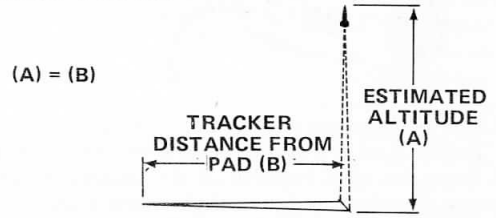
TABLE OF TANGENTS

Angle	Tan.	Angle	Tan.	Angle	Tan.	Angle	Tan.	Angle	Tan.
1°	.02	17°	.31	33°	.65	49°	1.15	65°	2.14
2	.03	18	.32	34	.67	50	1.19	66	2.25
3	.05	19	.34	35	.70	51	1.23	67	2.36
4	.07	20	.36	36	.73	52	1.28	68	2.48
5	.09	21	.38	37	.75	53	1.33	69	2.61
6	.11	22	.40	38	.78	54	1.38	70	2.75
7	.12	23	.42	39	.81	55	1.43	71	2.90
7	.14	24	.45	40	.84	56	1.48	72	3.08
8	.16	25	.47	41	.87	57	1.54	73	3.27
10	.18	26	.49	42	.90	58	1.60	74	3.49
11	.19	27	.51	43	.93	59	1.66	75	3.73
12	.21	28	.53	44	.97	60	1.73	76	4.01
13	.23	29	.55	45	1.00	61	1.80	77	4.33
14	.25	30	.58	46	1.04	62	1.88	78	4.70
15	.27	31	.60	47	1.07	63	1.96	79	5.14
16	.29	32	.62	48	1.11	64	2.05	80	5.67

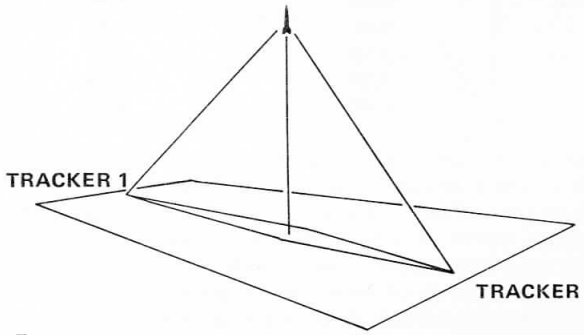
The tangent of this angle is found by checking the table of tangents. Multiply the tangent by the distance from the tracker to the launcher (baseline distance) to find the altitude.



A single tracker will give best results on calm days. Wind interferes with accuracy since models tend to tilt over into the wind as they fly. The result is that the rocket will not be straight over the launch site at peak altitude, but instead will be some distance over in the direction of the wind. To keep error due to drift to a minimum, locate the tracker at a 90° angle to the wind direction as shown.



In determining where to locate a tracking station, estimate the altitude your model will reach. The tracking station should be approximately this distance from the launcher (usually 500 to 1000 feet). Measure the distance from launcher to tracker carefully to insure accurate altitude calculations.



For more precision, use two trackers on opposite sides of the launcher. The easiest way of calculating rocket height using two trackers is to find the altitude for each tracking station and then take the average of these two altitude figures.

More elaborate tracking systems and more elaborate mathematics can be used to gain greater accuracy when the rocket doesn't fly straight up. However, a simple tracking system will do the job very well when good models are flown on calm days. More complete information on basic altitude tracking is contained in Estes Industries Technical Report TR-3.

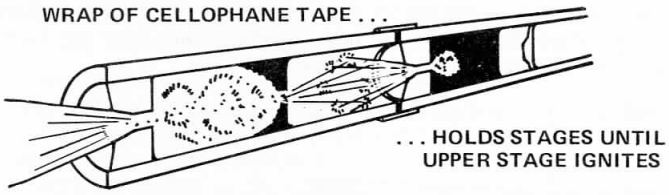
MULTI-STAGING IGNITION

FIG. 1A PROPELLANT

FIG. 1B RUPTURES HERE AS BURN CONTINUES

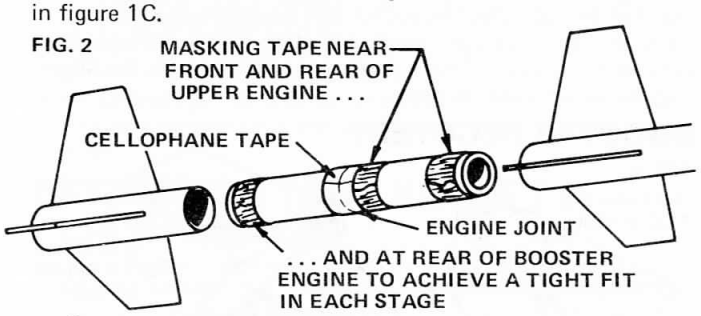
The first stage of a multi-stage rocket is always ignited by standard electrical means. Second stage ignition occurs automatically upon burnout of the first stage. Figure 1A shows that the first stage engine has no delay or ejection charge. This gives instant ignition of the next stage at burnout.

FIG. 1C



In Figure 1B the propellant is partially burned, leaving a large combustion chamber. As the propellant continues to burn, the forward wall of propellant becomes thinner until it cannot withstand the high pressure inside the chamber. At this point the remaining propellant wall ruptures, and the high pressure escapes forward toward the nozzle of the next stage carrying hot gases and small pieces of burning propellant into the nozzle of the second stage engine. This action is illustrated in figure 1C.

FIG. 2


MASKING TAPE NEAR FRONT AND REAR OF UPPER ENGINE . . .
CELLOPHANE TAPE
ENGINE JOINT
. . . AND AT REAR OF BOOSTER ENGINE TO ACHIEVE A TIGHT FIT IN EACH STAGE

For this system to work, the stages must be held together until the upper stage engine has ignited. When this happens, the stages must immediately separate in a straight line. This is accomplished by wrapping one layer of cellophane tape around the joint between engines and then recessing this joint 1/2" rearward in the booster body tube, as in fig. 2. Recessing the joint forces the stages to separate in a straight line.

FIG. 3

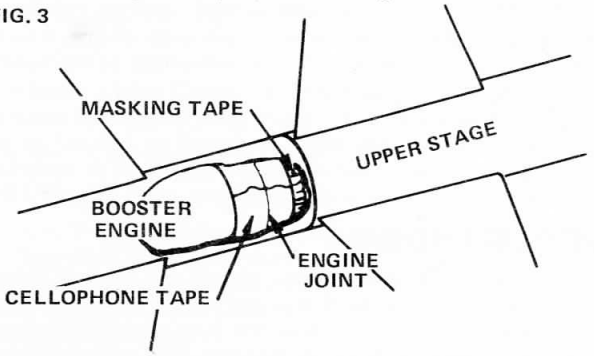


Figure 2 shows the engine installation in a typical two-stage model. Always tape the engines together before inserting them into the rocket. Check carefully before and after taping to be sure the engines are in their proper positions (nozzle of upper stage engine against top end of booster engine). Failure to check carefully can be embarrassing as well as damaging to the rocket.

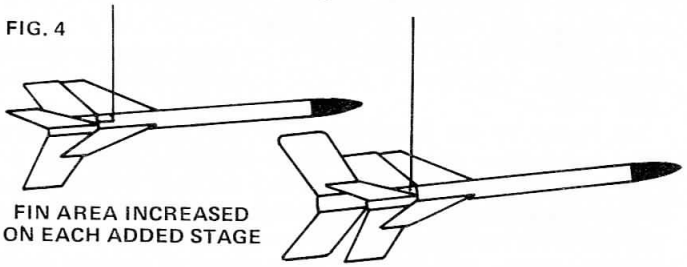
After taping the engines together, wrap masking tape around the upper stage engine at the front and near the rear as in fig. 3 to give it a tight fit in the body. Push it into place. Now wrap the booster engine and push it into position. Failure to get the upper stage engine in place tightly enough will result in the recovery system misfunctioning; failure to secure the booster engine tightly can result in its dropping off under acceleration.

Rockets using large diameter tube (BT-50 and BT-60) require somewhat different methods, but the same principles of tight coupling and straight line separation must be followed. Estes Industries Technical Report TR-2 contains detailed information on the design and operation of larger multi-stage models.

STABILITY

Since two or more engines are mounted near the rear of a multi-stage rocket, it has a tendency to be tail-heavy. To compensate for this, extra-large fins are used on lower stages. Generally the lower set of fins on a two-stage rocket should should have two to three times the area of the upper set. Each additional stage requires even greater fin area.

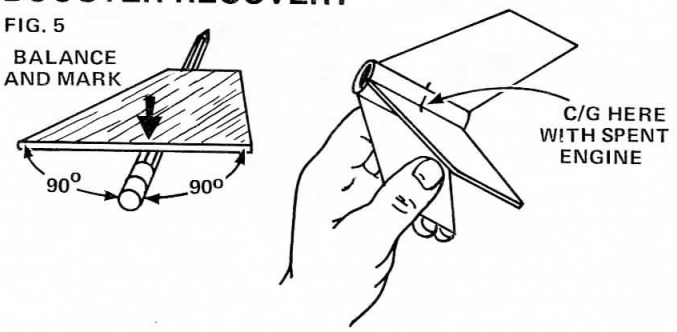
FIG. 4



When checking for stability, test first the upper stage alone, then add the next lower stage and test, and so on. In this way you can be sure that the rocket will be stable in each step of its flight, and you can loacte any stage which does not have sufficient fin area. Always check for stability with the largest engines to be used in place.

BOOSTER RECOVERY

FIG. 5



Most lower stages are designed to be unstable after separation. The booster should be built so that, with an expended engine casing in place, the center of the area of the fin (its balance point) matches or is up to 1/4 inch ahead of the booster's balance point. This way a booster doesn't need a parachute or streamer, but will tumble, flutter, or glide back to the ground. If the booster is to be used again, it should be painted an especially bright color, as it does not have a parachute or streamer to aid in spotting it once it is on the ground.

TYPES OF ENGINES

Lower and intermediate stages always use engines which have no delay and tracking charge and no parachute ejection charge. There is no delay so that the next stage will receive the maximum velocity from its booster. The engines which are suitable are those which have designations ending in zero, such as the 1/2A3-0T, A8-0, B6-0, and B14-0.

In the upper stage an engine with a delay and tracking charge and parachute ejection charge is used. As a general rule, the longest possible delay should be used. Engines suitable for upper stage use are those with long delays such as the A8-5, B6-6, C6-7, etc.

MODEL ROCKET ENGINE SELECTION

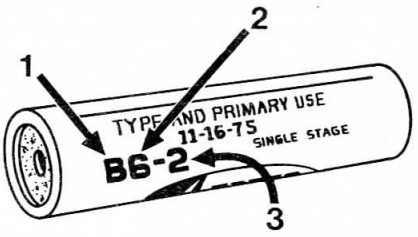
Model rocket engines are precision engineered and carefully manufactured power plants for model rockets. Each type of engine is designed for a specific type of mission.

Each rocket performs best with certain engines. The recommended engines for Estes kits are listed on the kit instructions and with the description of the kit in the Estes catalog.

Several sizes of engines are available. The tiny T Series Mini-engines can power the Mini-Brute model rockets and many standard solid propellant model rockets when used with a suitable adapter. The "standard size" engines are used to power most model rockets. These engines can even launch some "D power" birds when used with the proper adapter. D engines are available for launching large payloads and for maximum altitude flights with the rockets which are built to accept them.

ENGINE SIZES		
Engine Type	Length	Diameter
Mini	1-3/4 inch - 44mm	0.502 inch - 12.7mm
Standard	2-3/4 inch - 70mm	0.690 inch - 17.5mm
D	2-3/4 inch - 70mm	0.945 inch - 24mm

All engines produced by Estes Industries are given a code designation which provides the rocketeer important data on the engine's performance capabilities. Here's how to read this coding:



1 The first designation in the code indicates the total impulse (total "power") of the engine. The D engine as shown below has 32 times the total impulse of the smallest engine (1/4A). Engines are manufactured with slightly less than the maximum values to assure staying within their "class".

TOTAL IMPULSE CLASSIFICATION		
Code	Pound-Seconds	Newton-Seconds
1/4A	0.14	0.625
1/2A	0.28	1.25
A	0.56	2.50
B	1.12	5.00
C	2.24	10.00
D	4.48	20.00

2 The second designation, a whole number, indicates the rocket engine's average thrust in Newtons. (1 Newton equals 0.225 pounds.) For normal and most high performance flying an average thrust of 3 to 8 Newtons is best. For high lift-off weights and high acceleration studies, series II engines with an average thrust of 14 Newtons and the series IV (D) engines with 12 Newtons average thrust are recommended.

3 The last number following the dash gives the delay time in seconds from thrust burnout to activation of the recovery system (parachute) ejection charge. Engines with an "0" in this position have no delay or ejection charge and are used only in the bottom stage(s) of multi-stage rockets (Mini engines have "T" following this designation.) Use engines with short delays for heavier rockets, longer delays for lighter rockets.

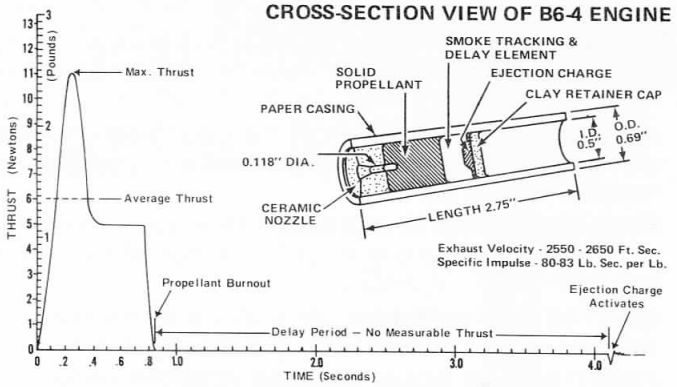
The label color indicates the recommended use. Green for single stage, purple (or blue) for top stage of multi-stage rockets, and red for booster or intermediate stages.

MODEL ROCKET ENGINES

Today's model rocketeer can choose from an amazing variety of engines to power his models. He has an engine available for almost every purpose.

The engines the rocketeer uses come in two main types: end-burning and center-burning. End-burning engines are by far the most popular with model rocketeers. They have a big advantage because they can be built to give a dual level thrust action as shown by the B6-4 thrust curve.

TYPICAL TIME-THRUST CURVE OF B6-4 SERIES I



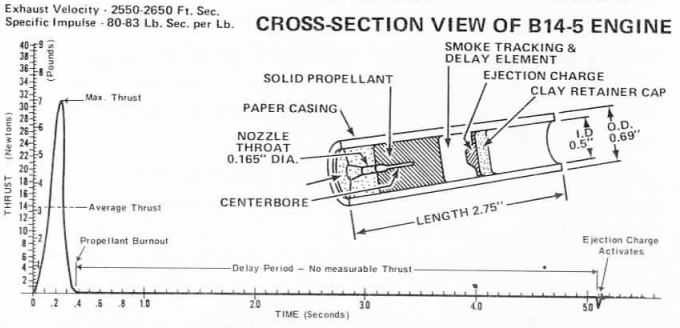
CROSS-SECTION VIEW OF B6-4 ENGINE

This design is especially effective with light-weight high performance rockets. The high initial thrust boosts the rocket to a suitable flying speed almost immediately; thrust then drops to a lower sustaining level to maintain speed and gain the most distance with the least fuel consumption.

For heavy rockets especially those carrying large payloads, a second type of engine is also available. The center-burning or core burning engine produces a very high average thrust, but only for a short period of time. This is more efficient for the heavy rocket since it brings the rocket to an adequate flying speed with less fuel than would be used by a low thrust engine. The B14-5 thrust curve is typical of center-burning engines.

Single and upper stage model rocket engines of both types operate in the same way after the propellant has been burned. As the last of the propellant burns it ignites a slow-burning smoke tracking/delay element. This "delay charge" produces no thrust, but lets the model coast upward, leaving a smoke trail behind.

TYPICAL TIME-THRUST CURVE OF B14-5 SERIES II

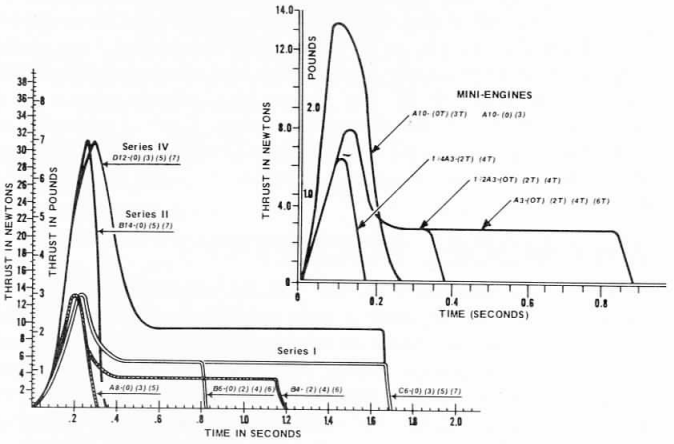


CROSS-SECTION VIEW OF B14-5 ENGINE

After several seconds the delay charge ignites an ejection charge which pressurizes the forward end of the rocket body to force the parachute out of the tube. (This gas pressure can be used instead to operate many types of recovery system other than parachutes.) If the correct engine is selected, ejection should occur at about the time the rocket has reached its peak altitude.

End-burning engines come in several sizes. The most common, known as Series I, is 2.75 inches long and 0.69 inches in diameter. A smaller type, the T series "mini" engine, is 1.75 inches long, and 1/2 inch in diameter. Center-burning engines are classified as Series II. For more complete information, see the performance graphs and cut-away drawings.

COMPARATIVE TIME/THRUST CURVES OF ESTES ENGINES



By studying the chart above you can learn much about the expected performance of your model using any type of engine.

For instance, looking at the curve for Series II engines and noting the extremely high thrust of the B14 engine, you'd know your rocket would accelerate quickly to a high velocity. Then, of course, at propellant burn out, it would also slow down quickly due to the high drag of a rocket traveling so fast. The question you'd ask yourself then is....Would my rocket go higher using one of the other B engines which provides less acceleration but keeps pushing for a longer period of time?

This rocket engine design and performance information is given for educational purposes only. We believe that if you understand how your rocket engine works you are in a better position to gain scientific knowledge from your activities and to design your rockets for specific purposes such as payload experimentation, altitude studies, drag racing, etc. We DO NOT grant permission for you to attempt to copy our design nor do we recommend that you attempt to build your own rocket engines.

ESTIMATING YOUR ROCKET'S PERFORMANCE

HOW HIGH WILL YOUR MODEL GO? The chart below shows the approximate altitudes that can be achieved with single stage rockets.

Engine Size	Altitude Range (depending on rocket size and weight)	Approximate Altitude in a typical 1 oz. model
1/4A3-2	50' to 250'	100'
1/2A6-2	100' to 400'	190'
A8-3	200' to 650'	450'
B6-4	300' to 1000'	750'
C6-5	350' to 1500'	1000'
D12-5	400' to 2000'	*1600'

(Some high performance models will reach higher altitudes than shown above.)
***When flown in a 2 oz. model.**

There are several things that affect the performance of a model. The first of these is engine size. The greater the total impulse of an engine, the higher it will boost a model.

WEIGHT

The heavier a rocket, the less altitude it will reach. A baseball can be tossed higher than an 8 pound cannon ball; the same holds true for model rockets. In addition, heavier rockets are more apt to tilt at an angle as they leave the launcher, reducing altitude even more.

On the other hand, it is also possible to build a rocket that is too light. Each design has an ideal weight for each engine type. Study Technical Report TR-10 to learn more about this.

WIND RESISTANCE

Drag, or wind resistance, is the third item which affects performance. The more drag on a rocket, the less altitude it will reach. A number of factors determine the amount of drag

on a rocket. The more frontal area the rocket has, the greater its drag will be. As a result, large diameter model rockets will generally not reach as great an altitude as smaller diameter rockets with the same engine power. Rough surfaces create turbulence in the air as it flows past the rocket, increasing drag. Smooth finishes will increase the altitude capability of the model. The stability of the rocket also affects drag – if it wobbles in flight, it will have greater drag. Careful attention to reducing drag can sometimes double a rocket's altitude capability. Aerodynamic drag is discussed in depth in Technical Report TR-11.

WHY MODEL ROCKETRY?

Few model rocketeers realize that the hobby they enjoy was started simply to provide a safe substitute for a dangerous activity. Yet, at the dawn of the space age, rocketry was one of the most dangerous sports possible for non-professionals. Experts estimated that a person had a one-in-seven chance of being injured or killed for each year he experimented with rockets. Newspapers told of fingers and eyes lost – and all too frequently of lives lost.

The rockets that killed were entirely homemade. The experimenter would obtain a metal container and fill it with a chemical mixture intended to serve as fuel. A Texas science teacher who tried this injured seven of his students and killed himself. A California boy made his rocket from a pipe filled with homemade fuel; it exploded during loading, killing him instantly and maiming his friend for life.

A SAFE PROGRAM

Model rocketry was developed to provide a safe alternative for the young person wanting to build a rocket. The first step was to make available a safe, low cost rocket engine, fully assembled, to eliminate the hazards of making one's own engine.

The second step was to initiate an educational program designed to make every potential rocket builder aware of the disastrous results of "basement bomber" type activities, telling him of the dangers of home-compounded fuels and metal rockets. The third step was to develop a line of rocket designs, launch equipment, payload instruments, and technical information to challenge the imaginative rocketeer and guide him safely through his "rocket career".

Four factors were responsible for the dangers of non-professional rocketry. Many young people had a very strong desire to build and launch their own rockets. Dangerous materials for building rockets were readily available at low cost. Little information on the dangers involved ever reached the potential rocketeer. Safe materials for rocketry were not available.

The success of this approach is shown by the fact that there are more active rocketeers today than ever before, yet the number of accidents per year is a very tiny fraction of those occuring 15 years ago. Model rocketeers now enjoy a sport that is safer than baseball, basketball, or swimming. That's been our goal here at Estes - - to make model rocketry the safe and exciting sport it is today.

As a model rocketeer you have joined over one million other enthusiasts across the country in the truly exciting Space Age Hobby. We are glad to have you with us and hope your activities will give you much enjoyment over the years.

TECHNICAL PUBLICATIONS

These Estes publications will help you become an expert in model rocketry. Consult the current Estes catalog for a more complete list of available publications and prices.

ROCKET STABILITY – TR-1: Easy-to-read report explaining how rockets are designed to fly properly, including a before-launch test to assure rocket stability. Cat. No. 84721

MULTI-STAGING – TR-2: A complete easy-to-understand report providing the information needed for designing, building, and flying multi-stage rockets. Cat. No. 84722

ALTITUDE TRACKING – TR-3: The classic work on simple altitude tracking for model rocketeers with easy-to-understand computation. Cat. No. 84723

REAR ENGINE BOOST-GLIDERS – TR-4: Basic information covering design, construction, and operation of rear engine boost-gliders. Cat. No. 84724

CLUSTER TECHNIQUES – TR-6: The complete report on clustering engines to launch larger payloads. Cat. No. 84726

FRONT ENGINE BOOST-GLIDERS – TR-7: Valuable information on designing, building, and flying front engine boost-gliders. Cat. No. 84727

MODEL ROCKETRY STUDY GUIDE – TR-8: A planned sequence of activities to guide anyone toward becoming an expert model rocketeer. Cat. No. 84728

ALTITUDE PREDICTION CHARTS – TR-10: Explains a relatively simple method by which aerodynamic drag and other atmospheric effects can be taken into account in predicting rocket peak altitude. Cat. No. 84730

AERODYNAMIC DRAG OF MODEL ROCKETS – TR-11: All factors that influence drag are explained, and practical examples of ways to minimize drag are given. Cat. No. 84731

MODEL ROCKET LAUNCH SYSTEMS: An easy-to-understand booklet covering basic electrical theory, launcher design, multiple launchers, and electrical math. Cat. No. 2811

SPACE AGE TECHNOLOGY: A comprehensive mini-text for use in aerospace education, science, and industrial arts classes. Cat. No. 2813
A "Teacher's Manual" (Cat. No. 2823) is available to educators.

ESTES MODEL ROCKET CONTEST GUIDE: Great for planning model rocket contests and meets. Features rules for exciting competitive events plus suggestions for contest organization. Cat. No. 2815

AEROSPACE EDUCATION AND MODEL ROCKETRY: An excellent teacher's guide for introducing model rocketry into the classroom. Cat. No. 2816
(Single copies free to educators requesting it on school stationery.)

ESTES GUIDE FOR AEROSPACE CLUBS: Features complete details for club organization and activities. Cat. No. 2817

MODEL ROCKET ENGINES – TN-1: Large time-thrust curves suitable for use in displays, plus other data. Cat. No. 84700

MODEL ROCKET ENGINE PERFORMANCE – TN-2: Technical information. Includes formulas for calculating engine performance. Cat. No. 84701

THE FINE ART OF PAYLOAD LAUNCHING – TN-4: Information on payload launching with data on possible payloads, available payload compartments, and suggestions on preparation and launch of payloads. Cat. No. 84703